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Contents

All correspondence relating to the publication of papers should be addressed to

Harry E. Jordan, Secretary—500 Fifth Avenue, New York 18, N.Y.

ERIC F. JOHNSON, *Editor* LAWRENCE FARBER, *Associate Editor*
DANIEL N. FISCHEL, *Managing Editor* ELIZABETH P. MCSHERRY, *Associate Editor*

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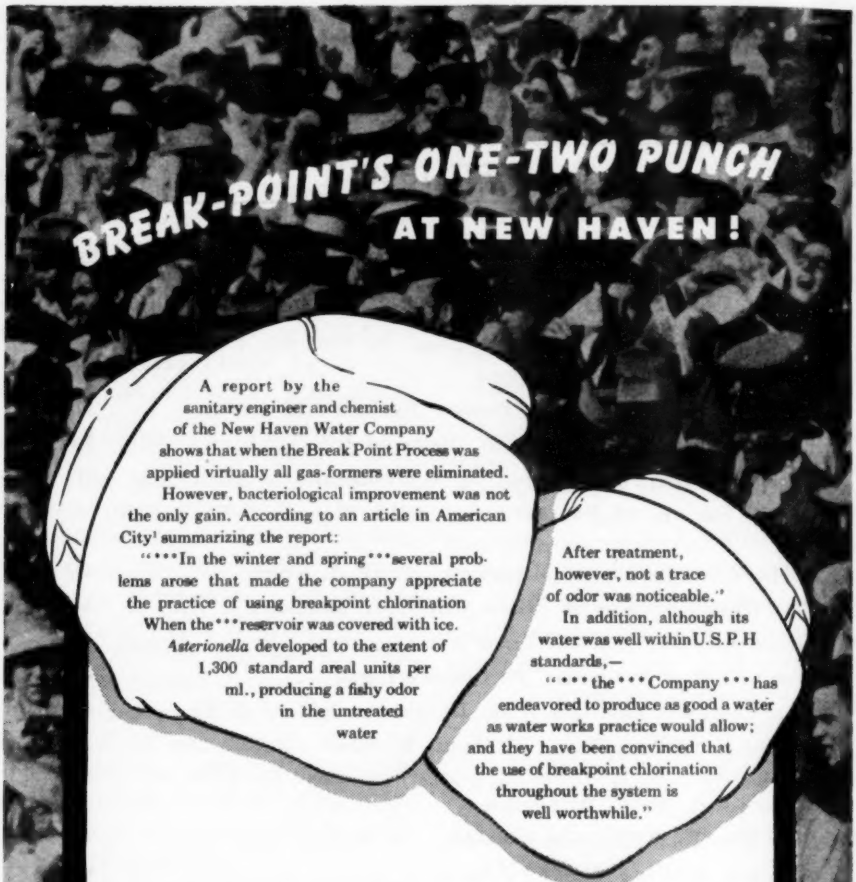
BREAK-POINT'S ONE-TWO PUNCH
AT NEW HAVEN!
A report by the sanitary engineer and chemist of the New Haven Water Company shows that when the Break Point Process was applied virtually all gas-formers were eliminated.
However, bacteriological improvement was not the only gain. According to an article in American City[1] summarizing the report:
"***In the winter and spring***several problems arose that made the company appreciate the practice of using breakpoint chlorination When the***reservoir was covered with ice. Asterionella developed to the extent of 1,300 standard areal units per ml., producing a fishy odor in the untreated water
After treatment, however, not a trace of odor was noticeable."
In addition, although its water was well within U.S.P.H standards,—
"***the***Company***has endeavored to produce as good a water as water works practice would allow; and they have been convinced that the use of breakpoint chlorination throughout the system is well worthwhile."
New Haven's experience is typical. Regardless of plant size, the Break Point Process can help you produce the kind of pure, palatable water consumers like. To find out how these and additional benefits such as—longer filter runs—iron and manganese removal—and color removal, can be obtained, check with your nearest W & T Representative
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The Water Department in City Planning

By Frederick A. Cuthbert

A paper presented on May 15, 1947, at the Pacific Northwest Section Meeting, Victoria, B.C., by Frederick A. Cuthbert, former Director, National Housing Agency, Seattle, Wash., and Assoc. Prof., Dept. of Landscape Architecture, School of Architecture and Allied Arts, Univ. of Oregon, Eugene, Ore.

CITY planning is of necessity a collaborative enterprise which, in order to obtain proper results, requires the best joint efforts of all city officials plus community-wide understanding and support.

To aid the city planning executive in his work a planning council should be established, composed of such key city officials as the assessor, building inspector, city engineer, water superintendent, fire and police chiefs, the city health officer, the superintendent of parks and also the superintendent of schools. This council should be independent of the official commission appointed by the mayor, its purpose being to advise and assist in the active job of planning.

The planning executive is not a superman with a profound knowledge of all things pertaining to the operation of the city's physical plant, nor can he be an expert in all the city's social, health, industrial, educational and recreational problems. But he should be a man of broad understanding of the principles and machinery of planning; a man of good judgment, able to administer and coordinate a planning program; and he should have more than average ability in public relations and salesmanship. He should radiate enthusiasm for the planning program and yet have infinite patience in its accomplishment.

Coming from many professions, city planners are prone to reflect their strongest professional heritage in the work they do. The architect as a city planner is likely to be most concerned about plazas, monumental building groupings and the general "city beautiful" aspects of planning. The sociologist as a city planner thinks first of the crime, the slums, the poverty and the problems of rehabilitation. The engineer may go statistical, concerning himself principally with percentages, formulas and graphs and with such practical matters as traffic, water supply and sewers. His standards of beauty are apt to be highly individualistic. The utilities engineer may get

as much aesthetic satisfaction from a perfectly aligned row of telephone poles as others do from an avenue of arching elms, and these two elements are not compatible. The ideal city planner would be a happy hybrid of engineer, architect and sociologist plus business-man, attorney, economist and diplomat. Until such a perfect combination has been attained in one man, municipalities would do well to employ as their permanent city planner the best qualified person they can hire, while expecting to supplement his services with such specialized assistants or consultants as he may need to do a well-rounded job.

Suburban Growth

During the past quarter century revolutionary advances have been made in city planning in line with the technological advances that have taken place in almost every field of engineering and science. Unfortunately, cities or parts of cities are not discarded and replaced when they are worn-out or outmoded, as are machines and equipment. Because of this fact, the evidences of advanced theory and practice in city planning are spotty and not readily apparent to the layman. Moreover, a city is a growing organism rather than a machine.

The growth of cities may be compared to that of the iris. If you plant a single iris and allow it to grow unmolested, in a few years it will have branched out and become a large, rounded clump. In time, however, the old rhizomes pile up in the center, withering and decaying, while about the periphery new irises continue to extend the circle. Many cities are in this condition today, spreading out over new areas while the center rots. Even the new growth is not necessarily good, because it may not be an orderly development of the sort that makes for better living. In the author's opinion, it is this unguided and often premature extension of urban land uses that must cause water works officials great concern.

Various forces are responsible for the outward growth of cities, a movement that was worrying them even during the depression when they had hundreds of vacant lots on the tax rolls. Today many cities, still with hundreds of vacant lots scattered through them, wonder how they can induce builders to use this developed property instead of building in new subdivisions beyond the city boundaries. The reasons given for going into the country include tax saving, freedom from city regulations, more living space and fresh air; however, such arguments often prove to be mere illusions after one considers transportation costs, higher utility rates, extra school expenses, the customary lack of adequate fire and police protection and the fact that the real estate speculator generally cuts the land up into city-size lots even in the country.

Of course, a large percentage of vacant city lots are either not available or are not desirable for residential purposes because the terrain is too steep or the lots are tied up in litigation, held for future owner use or located in blighted areas, commercial or industrial zones. Then, too, most city lots have been speculatively priced beyond their real use value. The exorbitant prices of city lots and of those in previously developed subdivisions have forced builders who are trying to meet the present urgent need for low-cost housing to seek inexpensive undeveloped land. Furthermore, developers have learned that important sav-

ings in construction costs can be made through mass construction and through the use of such technics as precutting, prefabrication of house components or on-site fabrication. To take full advantage of such processes they must be able to acquire large parcels of lots closely related to the site of their precutting and assembly operations. Scattered single city lots or small groups of lots do not lend themselves well to this procedure.

But we are not getting at the root of the trend toward living in the suburbs, which some day may empty the heart of our cities, unless we examine the basic shortcomings of cities for family living. Many urban sections are ugly, worn-out, run-down or just deadly monotonous. Lots are too small for a game of croquet and for even very modest flower and vegetable gardens. Houses are too close together for privacy or reasonable security from fire hazard. Blocks are too small, residential streets are miles long, carrying past each house a hundred times the traffic necessary, with all its noise, fumes and danger to life.

In the old days of city building no allowance was made for off-street parking, community play space or adequate safe distances between houses. For the most part, city streets followed the same pattern regardless of topography and were of the same width whether they served industry, business or residential uses. In other words, cities were not functionally designed and city building was controlled by speculators who had little or no concern for the lives, the happiness, the welfare or even the convenience of the inhabitants. We have inherited unforgettable examples of the lack of planning and of uninhibited greed and selfishness. Partly because of this past indifference and absence of foresight, cities all over the land are faced with the need for great and costly rebuilding programs.

Improvement of Run-down Areas

On the other side of the ledger appear those good and wise citizens who have sponsored parks, given or saved land for city squares and unselfishly used their energies to promote programs of civic betterment. Although they may now be mostly forgotten, we live in a better city because of them. Much about our cities is good, and a great deal can be readily improved. In large areas of our cities, much can be accomplished through simple face-lifting procedures.

Structurally houses do not differ greatly today from those built 200 years ago. Well-built, well-maintained houses do not lose their usefulness or livability in 25 or even 50 years or more. Neighborhoods deteriorate largely because of indifferent maintenance, which in turn is the result of depreciated living conditions due to the gradual intrusion of undesirable elements such as shops, taverns and gas stations. Next comes the overcrowding of houses with tenants in order to pay taxes on what the assessor considers to be potential commercial properties and has assessed at rates that are out of proportion to the present use values of the property. Often such areas are zoned for commercial use even though there is little possibility and no real need for them ever to be used for business purposes. This mis-zoning in itself discourages proper maintenance, because the owners see little point in spending money on upkeep when they think the houses will ultimately be torn down to make way for business.

Often such neighborhoods can be reclaimed if deterioration has not gone too far. Many an old residential street can be made very attractive and can retain its residential values for years by a bit of repair, remodeling and painting of the houses, and by planting trees and shrubs. These values ought not to be wasted, particularly when much of this older housing is physically better than or equal to what is being built today, and especially while good housing is so desperately needed. It would be to the advantage of most cities to campaign for the face-lifting of such neighborhoods.

Frequently dreary neighborhoods can be given a new lease on life by condemning the most substandard block of houses and then clearing and developing the block for park purposes, thereby letting in some freshness and sunlight. Well-maintained and attractive parks always appreciate the value of surrounding properties.

After all is said and done to improve run-down areas and use vacant city land, however, the fact remains that new housing will largely be built on outlying land, mostly beyond present city limits. These new developments present a challenge to all to profit by the experiences of the past; they afford an opportunity for the building of neighborhoods of lasting values and permanently good living conditions.

Regulations for New Housing

New subdivisions should be more than streets squared off to serve so many lots, because a new subdivision establishes on the land for all time to come a pattern confining and limiting the lives of those who will reside there. Subdivisions should not be established haphazardly but should result from carefully planned considerations of the tract or project as a part of the overall development pattern of the area. Certainly new subdivisions should not be on land that is too low and subject to flooding, although unrestrained speculative developers have been known to subdivide and sell such land for home sites. Nor should new subdivisions be permitted on the best sites for industrial expansion, thereby making them unusable or excessively costly for future industrial use.

A subdivision should not be approved which would exclude from public use the best possible location for a future park or school grounds. Planned community shopping centers, school sites and playgrounds are as important matters to consider in the design of neighborhoods as the streets themselves. Planning, zoning and subdivision regulations that help to put land to work for its highest and best uses certainly are in the best interests of the community as a whole.

Zoning

Of particular concern to water departments is the establishment of criteria for land development which will help them plan future extensions of service in an orderly and economical manner. Zoning for density of land use is an important step in this direction. If the water department can determine from the zoning map what the population density is to be in each part of its territory, the size and location of mains and extensions can be planned to provide for much greater efficiency and economy.

Density zoning establishes permissible ratios between open space and building space, based on the number of families allowed per acre. For example, in Madison, Wis., residence zone *A* requires 6,000 sq.ft. of lot area per family and zone *B*, 2,000 sq.ft. per family. Although zone *A* in Madison

is designated as a single-family zone and zone *B* as a four-family zone, it is questionable whether such designations are necessary. The original objections to permitting duplexes and multiple-family housing in the same zone as single family residences were based on the old practice of constructing apartments or flats so that they covered most of the lot on which they were built and frequently loomed high above surrounding houses, cutting off the light and air of their neighbors. Under density zoning, should a builder want to locate multiple units in an *A* residential zone, he could be permitted to do so without endangering the health, safety or even property values of his neighbors if he were required, for example, to allow 5,000 sq.ft. of lot area per family, to provide for off-street parking and loading, and to observe the same 2½-story height limitation commonly prescribed for single-family residences. On this basis, probably few multiple-family residences would be built, but it would be safe to permit them in single-family zones.

The *B* residential zone might have a minimum of 2,500 sq.ft. per family, with similar regulations regarding building heights and off-street parking and loading; and zone *C* might follow the Los Angeles *R*–3 zone, which prescribes a theoretical density of 26.4 families per acre—or 1,650 sq.ft. of lot area per family—and 35 ft., or 2½ stories, as a maximum building height; it also requires garage space for one car per family unit. Such regulations would encourage the development of garden court apartments, which can be very attractive. The regulations should, however, be sufficiently flexible to permit the acceptance of well-designed, multi-family projects in which the required open spaces could be pooled to provide for common play space, lawns and gardens. The Los Angeles ordinance also establishes a suburban zone restricted in use to single-family dwellings, museums and libraries, parks, playgrounds, golf courses and limited agriculture. In this zone 20,000 sq.ft. of lot area must be provided per family.

Role of Water System Engineers

It is evident that under such zoning and subdivision regulations the problem of planning utilities would be simplified, and water and sewer systems could be designed for greater economy with the assurance that they would be adequate for long-term needs. Here also the experience and knowledge of water department engineers is essential, for instance, in planning the location of water mains for best service to projected areas of development; in recognizing areas where problems will be encountered requiring an additional filter plant, storage basin or pumping station; and in deciding which areas should be developed first to make the most economical use of existing facilities. Professional advice is needed by the planner on matters of drainage and soils to help determine what sections are safe for septic tank use; how many families per acre should be permitted in such areas; and whether water from wells would be satisfactory in a proposed subdivision, or whether the planning commission should refuse to approve the plat unless the subdivider agrees to establish a satisfactory water supply system.

The water works official is urged to sponsor, promote and support a more intelligent, planned program for the development and redevelopment of his city and its environs. Professional men must be relied upon if this work is to be carried out. They see the problems and know by experience that

it is only through careful planning that cities can take the most advantage of their opportunities for better living, greater convenience, economy of operation and sound industrial and commercial progress.

Because of the decay and obsolescence that have been permitted to develop in our cities, over one-third of our families are living under conditions so bad that they are below the health and sanitation requirements imposed on dairymen in the care and housing of their cattle. We must get more of the country back into our cities, to relieve the tensions and irritations caused by city noise, traffic confusion and indecent housing.

Discussion

By Otto K. Jensen

Exec. Secy., Indianapolis Redevelopment Commission, Indianapolis, Ind.

The author's analysis of the problems resulting from poor planning and the lack of enforcement of zoning and building code regulations applies with equal appropriateness to most of the cities of the United States. Indianapolis has experienced the trend in which home-builders go to the periphery of the city—requiring the costly extension of city services and utilities—while much land remains vacant and unused near the center, where services are available without the expenditure of additional municipal funds. It is realized, however, that there are other hindrances besides high acquisition costs which prevent the immediate use of land within the city; some of these are the proximity of blighted areas, the smoke nuisance, the lack of recreation facilities, traffic hazards, poor health and sanitation facilities and excessive valuation for tax purposes.

The antiquated building code problem has recently been met by the adoption of a modern, comprehensive and progressive code which was sponsored and prepared by the Indiana State Administrative Building Council. It has generally been accepted and enacted by the legislative bodies of most of the municipalities of Indiana.

The author's comments on planning have been borne out by Indiana's experience. A great deal of planning has been prepared by the "expert," without proper consultation and with the public left in the dark; as a result, such plans are usually rejected by the public and become so much wasted effort. The writer strongly concurs in the recommendation for a planning council; Indiana has gone a step further in authorizing by law the appointment of advisory committees to the plan commission. These committees are to be representative of the community in order to obtain citizen participation in the planning processes, which will result in public support of the execution of the projects.

Indianapolis has also taken a forward step in doing something to make the vacant lots within the city more attractive for development.

In 1944 a Postwar Planning Committee of 150 of the city's leading business men, labor leaders and representatives of civic organizations was appointed by the mayor to study municipal needs in the postwar era. The subjects investigated by subcommittees included industrial development, employment, transportation, smoke abatement, airports, downtown parking, and housing and slum clearance.

The committee and its subcommittee on slum clearance had an earnest de-

sire to do something about the slums in the city. It was felt that blighted areas represent a heavy cost to the community in terms of disease, crime and degraded living conditions. After a thorough study of the slum areas of the city, the committee worked out a unique and practical method for the acquisition and clearance of blighted areas by the city and for their subsequent redevelopment under private enterprise. Out of such thinking came the Indianapolis Redevelopment Law, enacted by the 1945 session of the Indiana legislature and unchanged to date. Some highlights of the Indianapolis redevelopment program are worth presenting, because it is one of a very few which have advanced beyond the talking stage and are in actual progress.

Indianapolis Redevelopment Commission

Under this carefully written law, a redevelopment commission has been established, which has officially designated a tract of 178 acres as a blighted area. It has studied the area in detail and adopted a plan for its redevelopment which has been approved by the City Plan Commission. Cash on hand amounts to more than $1,100,000, raised by taxes during the past two years to accomplish this and later projects. Acquisition of property in the area has already begun.

The commission has the power to assemble the land by negotiation with owners or by condemnation if necessary; it has the resources derived from direct taxes; it has full authority to dispose of the land in accordance with an approved comprehensive plan; and it may require purchasers to conform to such a plan.

The Indiana legislature and the citizens of Indianapolis have accepted the principle that the public must assume the excess cost of acquiring, clearing and planning the re-use of slum areas. It should be noted, however, that the city will be compensated for such excess costs over a period of years through increased property values resulting in increased tax collections.

Indianapolis has chosen to pay as it goes. Although under the law deferred payment through bond issues is not permitted, this has been no stumbling block. Authority has been granted by the legislature to levy a tax of 10¢ on each $100 of taxable property the first two years, without review; thereafter up to half that amount, or 5¢ on each $100 of taxable property, may be levied, subject to the methods of reviewing tax rates and budgets used in Indiana.

The commission has withstood its first court test. The owners of affected property have the legal right to remonstrate and obtain a court review when the Redevelopment Commission has made an official decision to declare their property blighted and has announced its intention to acquire such property for redevelopment. Sixty-six of the 300 affected owners obtained a court review of the first commission project, and after extensive hearings the court fully sustained the commission's declaration. There has been no constitutional test of the law, but the time for that is not now so appropriate in view of the numerous uncontested actions of the board and the result of the single court test of the commission's administrative decisions. If a constitutional question is raised, however, it is believed the commission is on safe ground.

Of course, as much may be learned from experience as from all the advance theorizing. One of the most significant developments has been the unanimous conclusion that there is much to be salvaged in the redevelopment of the first area. The commission is definitely not going to scrap all existing sewers and utilities, street layouts or even houses which a little repair or rehabilitation will render suitable for many years to come.

It is very true that this may not present as beautiful an architectural layout as would result if the area consisted entirely of new housing, but the commission is convinced that it cannot justify spending public funds to acquire and destroy property that is so readily salvageable. Equally important, this salvaging job can certainly be accomplished without economic or social disadvantage to the new housing and the new residents and owners.

Indianapolis is embarked upon a continuous program. Already the commission is about to designate a second and smaller area as blighted. Incidentally, that area is to be redeveloped, not for housing, but for a very obvious industrial use. The commission's financial resources, it is hoped, will to a large extent become a revolving fund, as it acquires, re-plans and disposes of one area after another.

Conclusion

The Indianapolis program has several noteworthy advantages: (1) rebuilding costs, which are the largest costs in redevelopment, are met by the investment of private capital under private initiative; (2) the clearance of blighted areas and their redevelopment are planned to benefit the entire city rather than a particular segment of the population; and (3) the control of the program remains in local hands and the members of the commission are easily accessible to all individuals interested in presenting their views. It is firmly believed that redevelopment will be more soundly planned and executed if every urban community undertakes to work out its own solution.

Shutdown Procedure in Main Breaks

By Laurie M. Leedom

A paper presented on Nov. 7, 1947, at the New Jersey Section Meeting, Atlantic City, N.J., by Laurie M. Leedom, Constr. Engr., Division of Water, Newark, N.J.

ONE of the many benefits of modern civilization is the convenience of having clean water delivered to our homes and places of business. Like so many things in organized society which we take for granted, little thought is given to the water supply of a community until something happens to interrupt it. The most frequent causes of such interruptions are leaks and breaks in the pipes serving us. When such things occur it is the desire and duty of the water works operator to locate the trouble quickly and remedy it.

The subject of making a prompt shutdown has been given some thought and the procedure herein described is offered to those whose duty it is to repair the water pipes when they fail. Such failures are, in fact, rare occurrences, considering the miles—even hundreds of miles—of pipe underlying the streets of a city. But rare as they are, breaks do occur, sometimes with spectacular and even disastrous results. Few persons, other than those who have witnessed a bad break on a water main under pressure, realize the great amount of pent-up energy within a main. All water pipes are normally under pressure, varying from 30–40 to well over 100 psi. in some lines. In addition to this internal pressure the pipes are subjected to the vibration from heavy trucks and buses and also to expansion and contraction due to thermal changes. In spite of this constant torture, water pipes seldom break.

Pipe Grids and Valves

Water pipe sizes vary in different parts of a city, depending upon the type of service they perform. In the residential sections the pipes furnishing water to house connections and fire hydrants are small—generally 4, 6 or 8 in. in diameter. It is usual to have these pipes connected at each street intersection, forming a grid, and they are usually equipped with valves at every block. A leak in one of these pipes is often no more than an annoyance and inconvenience to the neighbors until it is repaired. The shutdown on such a line is very simple: it is only necessary to close a valve at each end of the block. The houses in that block will be without water until the repair is made but residents on the next street probably will not be aware that anything is wrong unless reversals in the flow dirty the water for a while. Even though the water is shut off in one block, it flows through the gridded pipe system in adjacent blocks with little or no interruption.

Large Mains in Industrial Areas

The large distribution mains supplying the industrial section of a city are laid out on a pattern somewhat differ-

ent from the small service mains in the residential areas. Manufacturing plants often require huge quantities of water, and the mains have to be of sufficient size to meet these needs. Being large mains they have large valves, which are not placed at every block but are hundreds—and often thousands—of feet apart. Shutting down such lines is not as simple as closing small service mains. It is harder and takes longer to operate the valves; they are much farther apart; and there are other difficulties which will be referred to presently.

Feeder Mains

Supplying all these distribution and service mains throughout the city are the feeder mains. These may be 36–72 in. in diameter, or in some cities even larger. Such mains are even more difficult to shut down. Since they convey the main water supply into the heart of the city, they may have to pass through some of the residential sections. Almost any size of water pipe is therefore likely to be found in a given street.

Leaks and Breaks

A small leak can occur in any pipe. Unless the water escapes in pervious soil, it comes to the surface as a trickle through the paving and the leak makes its presence known as a wet spot in the street. Such a leak requires reasonably prompt attention and repair.

When a large pipeline breaks, it creates a condition that demands an immediate, decisive and energetic shutdown. While a break even in a small pipe under moderate pressure can cause a lot of damage, a major break in a large high-pressure line can be actually disastrous. A broken 48-in. pipe under a pressure of 100 psi. sometimes results in a small geyser, and the force of the water hurls stones and dirt into the air and washes huge craters in the street. Ensuing flood conditions overwhelm the sewer inlets and the water flows into the basements of adjacent buildings, causing immense property damage. An example of such a break is shown in Fig. 1, which is a reproduction of a rather unusual photograph obtained through the courtesy of the *Rocky Mountain News* and the Board of Water Commissioners at Denver, Colo. The break occurred on a 36-in. main in April 1935. It is not often that a photographer is on the spot when a pipe breaks nor is there usually such a spectacular display. The tremendous force of the water is vividly portrayed and tells better than words why a water department should have the means for making a quick shutdown in an emergency. Sometimes the water, instead of flying through the air, acts as a jet against the fill surrounding the pipe, washing away large quantities of soil in a short time. In a paved street the water from a break often undermines the pavement, causing huge cavities that are not visible until the pavement drops in or fails under a passing truck.

Figure 2 shows the damage caused by a broken 48-in. main in Philadelphia on February 12, 1947, and Fig. 3 is a view of the flooded street resulting from the break. These two pictures are here reproduced through the courtesy of the Bureau of Water, City of Philadelphia, and the *Philadelphia Evening Bulletin*. The newspaper article accompanying the photographs stated that the main "burst at

4.05 A.M. with an explosive roar . . . and ripped three separate holes in the street, through which geysers spouted 12 ft. into the air. It unleashed a destructive, rampaging torrent which covered 24th Street from house-line to house-line to a depth of about 2 ft. and flooded the cellars of about 24 homes and stores up to the first-floor level." The force of the flowing water moved a parked automobile 40 ft.

FIG. 1. Major Break on 36-in. Main at Denver

Air-Raid Drills

The problem of handling main breaks, though serious in peacetime, becomes greatly magnified during a war period. Because of the likelihood of main breaks due to bombing and other enemy action, efficient procedures for shutdown and repair are more than ever necessary.

One of the sidelights on the recent war relates to this very matter of making quick and intelligent shutdowns and establishing alternate supplies of water in the event of enemy bombing. It seems that when civilian defense procedure was set up, little or no consideration was given to the very important matter of water supply to combat the fires that would result from air raids. Despite the well-known experience of foreign cities, where bombs broke water mains by the dozen and whole sections of towns were burned to the ground for lack of

water, civilian defense officials at Newark, N.J., apparently ignored the importance of the vital water supply and set up a program whereby all traffic was to be stopped when the "red" signal was sounded. This, of course, included the water department trucks, as well as the men reporting for duty on foot or in their cars. Bombing would have inevitably broken the mains and resulted not only in the waste of much-needed water but also in the reduction of the pressure throughout the city to such an extent that even undamaged supply lines would have been useless. Even now it seems incredible that such a stupid arrangement could have been approved, yet there it was and no one could do anything about it.

Fig. 2. Result of Philadelphia Main Break

The situation was explained many times, in great detail, to civilian defense officials. Subsequently special passes for the men, and markers of various sorts for the trucks and cars, were issued to the water department, but the damage had already been done. By that time the public had been drilled into seeking cover when the sirens were sounded and any one not doing so was considered to be a violator of the law. Misguided citizens and air wardens, city police and—incredibly—even the U.S. Army, stopped water department personnel with abusive language, stones and even bullets. If Newark had been bombed under the conditions prevailing at that time, the major portion of it undoubtedly would have burned down for lack of water.

To learn if this unbelievable situation was confined to Newark alone, the author made a survey at the time. Ques-

tionnaires were sent to water departments in all American cities of 300,000 population or over, asking, among other things, what their experience had been in getting water department trucks and employees to their posts during air-raid drills. The amazing result of this survey was that practically all of these cities throughout the country reported the same trouble with civilian defense procedures that Newark had encountered! If another war should ever threaten this country, provision certainly must be made to let the water departments function during a raid or we shall invite swift and certain destruction of our cities by fire. Waldo G. Bowman (1) states that Berlin had 52 breaks in five 48-in. parallel mains within a distance of a little over a mile, and a total of over 2,300 breaks in mains for the whole city. What could American water departments have done under similar conditions, hamstrung as they were by civilian defense regulations?

Planned Procedure Needed

In peace or war it can be seen that shutting down a large main for a major break is not a casual operation, but one calling at once for:

FIG. 3. Water Running After Shutdown

1. *Speed,* both in receiving notification that a break has occurred and in getting a crew to the scene promptly and shutting the valves, even though they may be numerous and far apart;

2. *Training,* so that the crews will be familiar with the instructions and will be able to read and carry them out quickly;

3. *A previously planned procedure* listing the right valves to close—all of them—to effect the quickest shut-

down, and the proper valves to be opened to furnish an alternate supply to the affected area.

These are not qualities that just spring up in water department crews spontaneously and unaided. Unless emergency programs have been worked out in advance, to the last detail, an untrained crew cannot be expected to make an efficient shutdown.

Most water departments have probably, at some time or other, experienced a bad break in a main pipeline. A well-trained crew will make the shutdown in an orderly and efficient manner. A crew which is less than well trained may not only put on a frightful exhibition of inefficiency and apparent stupidity, but can also squander precious minutes while otherwise valuable water is going to waste through the break and an infinitely greater loss is being sustained in the form of property damage caused by the flood.

It is quite obvious that a quick and efficient shutdown can be accomplished only by giving the matter careful consideration before a break occurs. There is a certain amount of excitement and confusion attending a bad water main break, which is not at all conducive to the clear thinking needed to make the shutdown in the shortest possible time. A comprehensive plan should therefore be prepared, somewhat along these lines:

1. There must be some means of knowing, as quickly as possible, when a break occurs, and on what main.

2. This information should be transmitted to headquarters and also to the repair crew in the shortest possible time.

3. The person in charge of the crew should have with him a detailed program showing exactly what valves are to be operated to effect the desired results—that is, to shut down the broken line and to set up the best possible alternate supply to the area affected by the shutdown.

4. The broken line must be drained as soon as possible to prevent unnecessary flooding through the break and also to prepare the line for repairs.

Recording Meters on Large Mains

Valuable time can be saved in receiving initial knowledge of a break by the use of recording rate-of-flow meters and recording pressure gages on strategic mains. These can be installed at control points, such as water treatment stations and filtration plants, where attendants can note any sudden increase in flow—or drop in pressure—and notify the main office by telephone. Such meters and gages can be equipped to operate a bell or light to attract attention when the flow or pressure is abnormal. The paper dial or roll from these recorders provides a permanent record of the time a break occurs and also indicates when the service is restored to normal. This record may prove very valuable as evidence in a subsequent damage suit, or it may be used in an employee training program as an example of a good or bad performance, as the case may be.

Short-Wave Radio

When an abnormal condition of flow has been noted, no time should be lost in notifying the crew that will make the shut-off. Water department cars and trucks should be equipped with short-wave radio. Two-way radio, with a separate transmission station for the water department, is the best arrangement, but some cities, such as Newark, use one-way radio, the mes-

sages being transmitted by the police department radio station. Each car and truck in the water department equipped with radio has an individual call letter, and when the crew is needed the radio operator gives the call letter and the office to which the driver will report. As soon as the message is received, the driver calls the department on the nearest pay-station telephone and receives further instructions. The Newark Division of Water has used one-way radio since March 1941, but consideration is now being given to the use of two-way communication with 24-hour transmission and maintenance service to be furnished by the Bell Telephone Co. on a rental basis. This will probably be installed in the near future, thus saving more time in notifying the crews, as the men can be receiving detailed instructions while on their way to the break.

Newark Method

A method originated and designed by the author for operating the feeder mains in the Newark Water System has been in use since 1940.

A program of procedure is set up for each main whereby any section of the line can be shut down in the shortest possible time and with the least disturbance to the rest of the system. Each main is given separate and detailed study. The portion of a pipeline between two adjacent main valves is called a section, and all the operations necessary to shut down a section are carefully considered in their proper sequence. Consideration is then given to the effect of such a shutdown on the remainder of the system. Usually the closure of a large main deprives some portions of the community of water, or at least seriously affects pressures. By opening certain other valves such a deficiency can usually be relieved. If such relief is not possible, it may indicate a weak spot in the water system for that locality, pointing to the necessity for building new supply lines. Finally, blowoff valves must be opened to drain the line quickly so that repairs can be made. It is important to check air valves during this part of the procedure. If they do not open properly, air cannot enter the pipe to replace the receding water and a partial vacuum will be created within the pipe. Subatmospheric pressure may result in the collapse of pipe made of steel plate. Unfortunately some mains blow off into sanitary sewers, and if the air valves do not function properly, air can, under certain circumstances, be drawn from the sewer into the pipe. Because some harmful bacteria are air-borne, it is possible to contaminate a main in this way. Separate blowoff vaults, not connected with a sewer, are much more sanitary.

All the information for shutting down, providing an alternate supply and draining the line is carefully prepared and tabulated on an "operating sheet." A similar compilation is made for each section of each main in the system.

Each valve in the city, with the exception of those for hydrants, is numbered and its location recorded. In a city street the valve box is referenced to the curb lines. Valves outside the city are referenced to posts, trees or special concrete markers. Therefore, on the operating sheet each valve to be operated is indicated by its number and location. The valves are listed in the proper sequence, so that it is necessary only to take each valve in turn and operate or check it as directed.

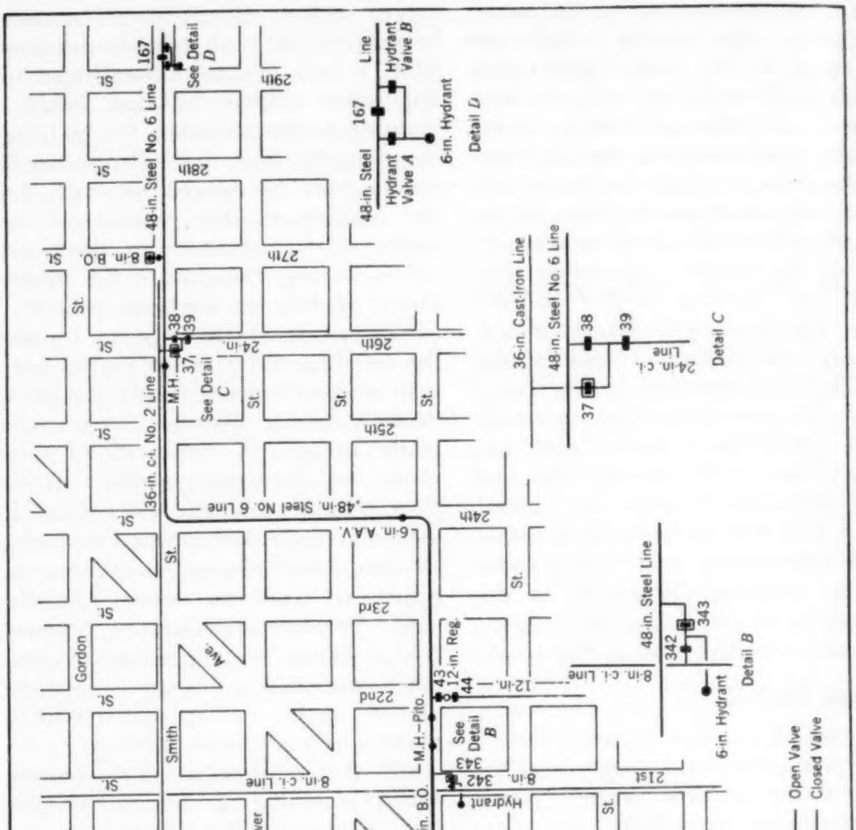

FIG. 4. Sample Street Plan (Diagrammatic)

It is very important not to take any valve position for granted. Even if the operator "feels sure" that a valve is either open or closed, he should check it. Valuable time can be lost by assuming that a valve is in a certain position and then having to return later when it is found that a shutdown has not been effected.

The person in charge of the crew has only to follow the instructions on the operating sheet line by line. When they have all been complied with, the pipe is shut down; and as soon as the water drains out, work can be started on the repair.

When the line is being filled, preparatory to restoring it to service, the air valves should be checked again to see that all the air is expelled from the pipe and that the valves do not leak when the water comes on. This applies to automatic as well as nonautomatic air valves.

To amplify the operating sheet and make the instructions more understandable, a "sectionalizing diagram" is prepared for each feeder main. This diagram is not to scale nor does it conform with the alignment of the pipe. Instead, the pipe is represented by a single, heavy straight line. Valves, hydrants, blowoff valves, air valves, pressure regulators and other appurtenances are indicated by symbols, which are the same on all sectionalizing diagrams.

Pipe Layout Maps

Figure 4 shows a street plan on which is drawn a 48-in. steel pipeline, together with various valves and connections in one of the sections. This is not the plan of an actual line but rather of a hypothetical water main showing most of the appurtenances found on pipelines.

It will be noted that the street plan is out of proportion, the streets being too wide for the block lengths. This distortion was necessary in order to show the valve locations and at the same time keep the section of pipe, with its various connections, air valves and blowoffs, within the confines of the drawing. The sketch was prepared to illustrate an idea rather than an actual street layout. The intention was to get as much detail as possible in a relatively small area and then to show how it would be represented on the sectionalizing diagram.

Sectionalizing Diagram

Figure 5 is the sectionalizing diagram that would be made for the section of pipeline in Fig. 4. To save space only one section is shown, although in actual practice three, and sometimes four, sections appear on one drawing, and blueprints of it are folded several times to fit in a $10 \times 11\frac{1}{2}$-in. ring binder. The length of a sectionalizing diagram depends, of course, upon the number of connections, valves, manholes and so on, in that particular section. The diagram for a run of pipe with few appurtenances would be very short. It has been found undesirable to use prints that are longer than 40 in., as they become unwieldy in the field, especially in windy weather.

Starting from the right, the pipe follows Smith St. to 24th St. to Clark St. to Park Ave. to Market St. to 15th St. Because it is not practical to show these turns on the diagram, the pipe is depicted as a straight line and above it are the names of the various streets in which it is laid. Small "north point" arrows are shown for each street so that the direction of the pipe may be more readily recognized.

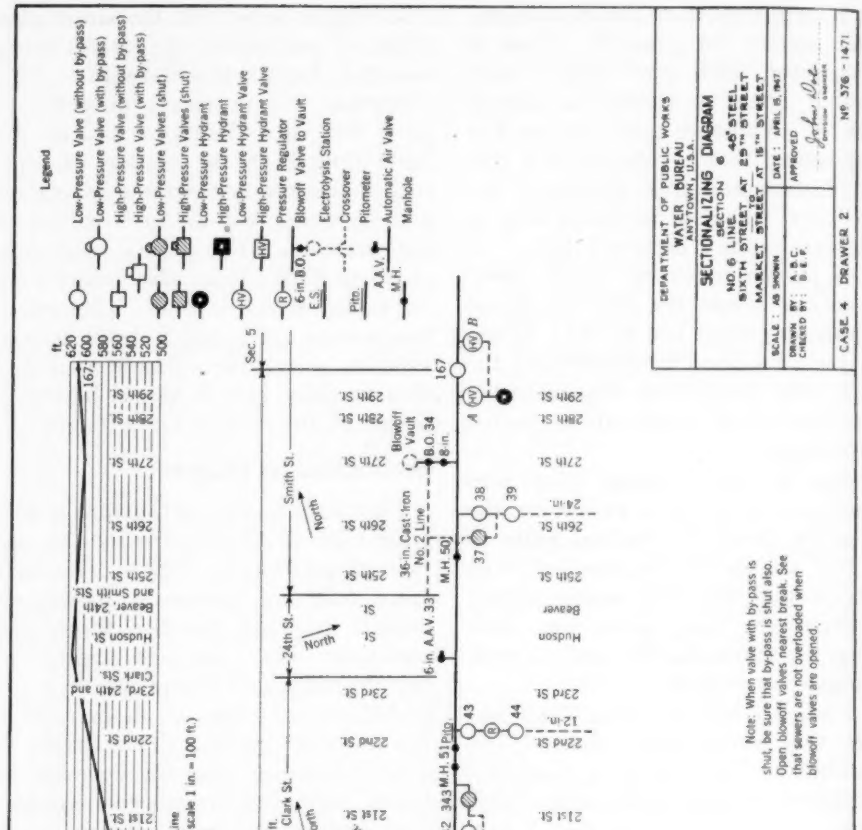

FIG. 5. Sample Sectionalizing Diagram

Streets crossing the pipeline are indicated by having the street name form the approximate angle with the line representing the pipe. This is to identify the location of valves, connections and the like; since the diagram is not to scale, and one block may contain several such valves and connections while several adjoining blocks may have none, the latter streets are bunched together in order to save space. The symbols are self-explanatory and can be easily identified with the things they represent on the street map.

Pipeline Profile

A profile of the pipe is shown above the diagram. Since the diagram is condensed, the grades appearing on the profile are not the true grades of the pipe; but this is immaterial as it is only essential to know the elevation of the low and high spots in the pipe. The total length of the section is also given. This is of considerable aid in determining the time needed to empty or fill the line, because a rough calculation gives the volumetric content of the pipe. The profile often shows that it is necessary to empty only a portion of the pipe to make a repair, thereby eliminating the waste of time and water in draining other parts of the line needlessly.

It will be noted that certain data not required for shutting down the line—such as pitometer taps, electrolysis stations and manholes—are shown on the diagram. This is for the benefit of the maintenance crews, who use these diagrams for reference in their regular daily work. Showing all the appurtenances connected with the pipelines in diagrammatic form makes for greater readability than the usual pipe plans and maps.

Operating Sheet

Figure 6 is the operating sheet for the section shown in Fig. 5. To simplify the directions each valve is identified only by its number and street corner, as "Valve 167 Smith St. at 29th St." For a person thoroughly familiar with all the main control valves this may be sufficient, but, as a further aid in locating the valve, a list is included at the bottom of the operating sheet, giving the valve number, the size of the valve, the number of turns and the location of the valve box in relation to the curbs of the streets at the top of the sheet. For example, "Valve 167" is an 18-in. valve, has 75 turns and is 38 ft. 4 in. north of the north curb of 29th St. and 5 ft. 0 in. west of the west curb of Smith St. It is a cone valve in a vault, and from its location "west of the west curb" the operator knows the vault manhole is in the sidewalk.

The operating sheet is designed to show which valves should be operated and in what sequence. Note that the operator starts by closing Valve 167, on the assumption that this is the valve nearest to the crew headquarters and would be the end of the section reached first by the crew responding to a shutdown order. The shutdown then proceeds, valve by valve, to the end of the section, permitting the crew to cover the section in the shortest time. If it should be desirable not to take the valves in turn geographically, the operating sheet can be made up accordingly and the crew will operate them as shown. Usually, however, it is best to operate the valves in sequence from one end of the section to the other to save time.

It will be seen from the sample sheet that "Operation B—Provision for Alternate Supply" takes the crew back

No. 6 Line—48-in. Steel 4/15/47

Section 6

Smith St. at 29th St. to Market St. at 15th St.

Operation A—To Shut Down Line

Shut Valve 167	Smith St. at 29th St.
Shut Hydrant Valve *A*	Smith St. at 29th St.
Shut Valve 38	Smith St. at 26th St.
Shut Valve 43	Clark St. at 22nd St.
See that Valve 343 is shut	21st St. at Clark St.
See that Valve 735 is shut	Park Ave. at Market St.
Shut Valve 168	Market St. at 15th St.
Shut Valve 17	Market St. at 15th St.
Shut Valve 18	Market St. at 15th St.
Shut Valve 19	Market St. at 15th St.

Operation B—Provision for Alternate Supply

See that Valve 180 is open	Locust St. at 15th St.
See that Valve 342 is open	21st St. at Clark St.
Open Valve 37	Smith St. at 26th St.
See that Hydrant Valve *B* is open	Smith St. at 29th St.

Operation C—To Unwater Line

Open Blowoff Valve 34	Smith St. at 27th St.
Check Automatic Air Valve 33	24th St. west of Clark St.
Open Blowoff Valve 35	Clark St. at Park Ave.
Check Automatic Air Valve 34	Park Ave. west of Market St.
Open Blowoff Valve 36	15th St. at Market St.

Main Valves				By-pass	
Valve	Size	Turns	Location	Location	Turns
	in.		*ft.-in.* *ft.-in.*		
167	18	75	38-4 NN, 5-0 WW	Cone valve in vault	
Hyd. *A*	6	19	13-5 NN, 5-2 WE		
38	24	195	8-7 SN, 3-1 EE		
43	12	36	12-8 NS, 1-7 WE		
343	8	24	8-10 SN, 21-6 EE		
735	12	36	12-3 NN, 4-0 WW		
168	18	75	18-3 SS, 5-0 WW	Cone valve in vault	
17	20	126	16-4 NS, 7-6 EW		
18	20	125	9-10 NS, 7-6 EW		
19	20	126	3-4 NS, 7-6 EW		
180	36	452	8-8 NS, 15-0 EW	1 ft. 2 in. SS, 15 ft. 0 in. EW	20
342	8	25	9-8 NS, 21-6 EE		
37	24	196	2-2 NS, 3-0 EE		
Hyd. *B*	6	19	53-9 NN, 5-2 WE		
B.O. 34	8	25	12-6 NS, 4-1 EW		
A.A.V. 33	6		5-0 SS, 65-6 WW		
B.O. 35	6	19	11-8 SN, 5-9 EW		
A.A.V. 34	6		5-0 SS, 52-8 WW		
B.O. 36	8	25	8-4 SN, 3-1 EE		

FIG. 6. Sample Operating Sheet

over the section, opening or checking valves, to the starting point. Unwatering the line, in either a part or all of the section, requires a third trip. This is much less travelling than is sometimes involved when a crew without an operating sheet rushes aimlessly back and forth over a section half a dozen or more times, searching for the proper valves to make a shutdown.

Periodic Valve Inspection

Even when an operating sheet is used, time can still be lost in making a shutdown if the valves do not seat properly. This may be due to a damaged valve, lack of lubrication or corrosion accumulating under the valve discs. Systematic, periodic inspection and operation of valves will reduce the trouble from these causes to a minimum. All valves, including the large control type, should be fully operated in each direction periodically; at the same time they should be inspected for defective parts and fully lubricated. The valves should also be tested for shut-off. On some of the main pipelines it may be necessary to set up a special schedule and do the work at night, or whenever it will cause the least inconvenience to the consumers.

Whether the testing is done by day or night, however, it is time well spent. Only in this way can it be assured that the valves will be in an operative condition when needed. It can never be absolutely certain, of course, that a mechanism will function; mechanical failure can occur at times on even the best-maintained machine. How much greater, then, is the chance of failure on a mechanism, even one as simple as a valve, that is placed in the ground and left for years without attention?

It cannot be overemphasized that the inspection should include a full operation of the valve—all the way down and all the way up, or vice versa—and not merely a few turns one way and then the other. Such a perfunctory operation test indicates little more than that the upper portion of the valve stem is not seized, or "frozen," in the packing gland. The stem may be bent or broken; the discs may have dropped or there may be an obstruction in the bottom of the valve body that would prevent a shut-off. Any one of these defects might exist, which would prevent complete operation, and still the valve could be operated for a few turns. It is necessary to make the shut-off and see that the water stops flowing. If this produces "dirty water," the main can be flushed out. At least it will be known that the valve shuts off. Otherwise, self-deception will waste valuable time in an emergency shutdown.

Maintaining Current Records

Operating sheets and sectionalizing diagrams should be kept up to date, and the latest revision date should be marked on each sheet. Changes in valves, connections, method of operating the system or anything else pertaining to the main should be promptly recorded and new prints distributed to the crews, the old sheets being collected and destroyed. The duty of keeping these records current and seeing that they are published should be assigned to a responsible person in the engineering office.

The men in charge of operating valves should study the operating sheets and sectionalizing diagrams and become thoroughly familiar not only with the location of the valves but with the sequence of procedure. It is also very important that the operator have

a good idea of the valve locations, as a covering of snow over the street boxes, and over the curbs from which measurements are taken, greatly hampers the task of locating the valves.

Valve-operating Mechanism

Small gate valves are operated by hand in Newark, but 20-in. valves and larger are worked by Payne Dean and Co. valve-operating mechanisms on the repair trucks, as shown in Fig. 7. Newark has two such mechanisms in service to operate 20- to 48-in. gate valves. Power is furnished by the truck engine and a safety shear-pin protects the valves from excessive strain and damage. Special valve keys with square, telescoping stems are used to operate the valves with this machine. There is an automatic revolution counter on the machine and the number of turns for each valve is shown on the operating sheet.

FIG. 7. Maintenance Truck Equipped With Valve-operating Machine

Cone Valves

Eventually cone valves will replace gate valves as main-control valves throughout the Newark system. Cone valves require far less time to operate and have the added advantage that, regardless of size, they can be operated by one man. Figure 8 shows a 24-in. cone valve installed in a 60-in. transmission main conveying 50–80 mgd. from Cedar Grove Reservoir to the center of Newark. The hydraulic loss through the valve and the Venturi reducers is negligible. Figure 9 is a close-up of the same cone valve in the vault. It can be operated from the street by means of a valve key passing through a valve box set in the vault roof, or by means of the 10-in. crank handle

welded to the operating nut. For the latter method only one hand is needed to operate the valve fully, a procedure which requires only 72 turns. The water pressure is 52 psi., and the valve has been operated easily against a full unbalanced hydraulic head. The 60-in. line in which the 24-in. cone valve is installed can be shut down or opened at this point in a few minutes by one man, whereas 48-in. gate valves on the same line require six or eight men, if operated by hand. The latter valves have 450 turns and therefore take about three-quarters of an hour to open or close.

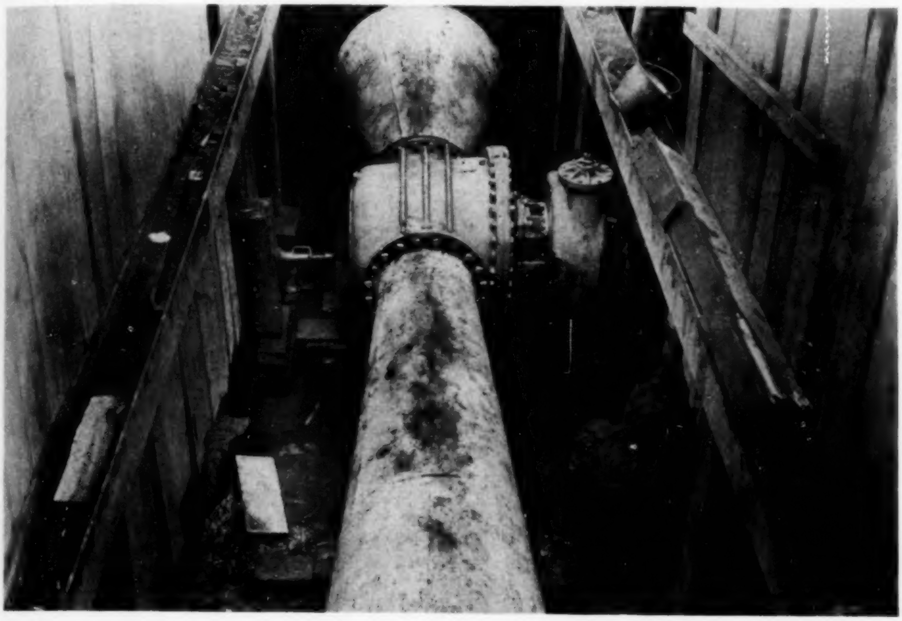

Fig. 8. Cone Valve Installed in Feeder Main

Safety Precautions

In addition to the saving of time and operating expense, cone valves have another advantage over gate valves—the safety of the men operating them. Gate valves, even when enclosed in vaults, are operated by placing a key on the operating nut of the valve and turning the key, either by hand or mechanically. Since the valves are almost invariably out in the street area, the men have to work in traffic. This is always a dangerous condition but it is especially hazardous at night or during bad weather, when the view is obscured. It is therefore a good precaution to furnish these crews with the best kind of danger flags and flashing red electric lamps sufficiently large to be seen by approaching motorists and mounted high enough above the pavement to be visible over the tops of cars, buses and trucks. In line with good safety training, the men should be instructed to stay in a group when stepping off the curb into street traffic, instead of straggling out one by

one. In spite of all these precautions the efficiency of the men is bound to be lowered if they must think of their personal safety while out in the street with cars passing by.

Since cone valves can be easily operated by one man, it is usually possible to construct the vaults so that the manways come in the sidewalk area. The operator can therefore enter the vaults and operate the valves from inside without going out into the street traffic.

Electric Lighting for Vaults

Weatherproof electric lights in the vaults and rustproof built-in ladders greatly aid the men in their work and add to their safety. The vaults should be wired for electricity but need not be connected to a power line. Instead, a waterproof socket at the entrance to the vault will receive the plug of a portable generator. This will provide adequate light in the vault when needed, without the possibility of the lights being left on inadvertently, the danger of a short circuit or the expense of a stand-by service charge from the electric company. Electric-light sockets can be bolted to the ceiling of the vault or built in when the roof slab is constructed, thus eliminating troublesome extension cords with frequent lamp breakages and annoying, or even dangerous, shocks to men who may be working in water and come in contact with an exposed wire in a worn extension cord.

Remote Control Operation

Some cities operate the main valves by built-in electric motors or by a hydraulic mechanism actuated by an electric control apparatus either at the valves or from a remote center. Such equipment saves valuable travel time in an emergency shutdown. Main lines can be closed and the pressure relieved by an operator in a central office. Limit switches protect the valve mechanism from overdrive, and electric contacts light position-markers in the central office, showing the operator when each valve is completely opened or closed. These layouts can be further supplemented by electric recorders showing pressures and rates of flow in various lines, all the data being

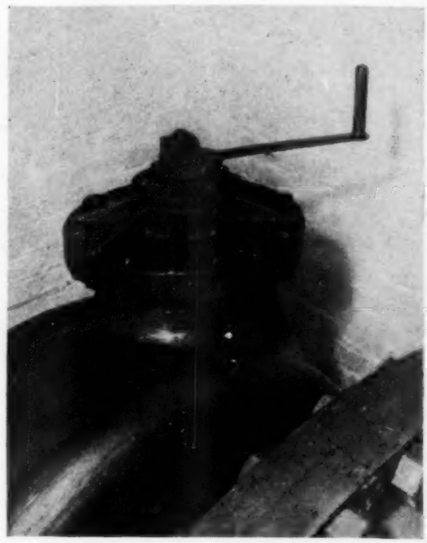

FIG. 9. Close-up of Cone Valve

transmitted electrically to the control center.

Emergency Stand-by Schedule

Several years ago an emergency stand-by schedule was established in the Newark Division of Water. A skeleton force of key engineering and supervisory men are available on call at all times. The ordinary leaks and trouble complaints are investigated and disposed of in a routine manner by the regular repair crews or by the

24-hour emergency crew. If something unusual occurs, however, the superintendent or an acting superintendent can be called for consultation or to take charge of operations. If a break should occur on a large main, or if some emergency should arise necessitating changes in the main water supply, the division engineer or an acting division engineer is available.

It may be of interest to mention here an emergency kit that is always ready to be picked up on a moment's notice and contains data and equipment which might be needed. The kit is a small metal suitcase which holds a complete set of maps showing the reservoir layouts, the transmission mains from the watershed intake to the city, all the feeder mains and the distribution system within the city. Included also are detailed maps of important intersections or control points and a set of operating sheets and sectionalizing diagrams. In addition to the maps the kit contains a pressure gage, gage fittings, a small Stillson wrench, a tape line, pencils, pads and a flashlight with extra batteries and bulbs. The maps in the kit are kept up to date and the gage and flashlight tested to insure their full usefulness whenever needed. Fortunately, the kit has seldom been used but it is there, with all the data and equipment, as insurance against the loss of valuable time so often spent in looking up information to help cope with trouble.

To deal with emergency calls after working hours, the stand-by schedule provides for the presence of the division engineer or someone representing him; the superintendent, an assistant or some other qualified person; and an engineer to establish headquarters at the division engineer's office. The latter's duty is to coordinate work in the field, arrange for needed material and equipment, consult files or records and answer the telephone. Under this schedule the engineers are available on call for one in every six weeks. It is very seldom that any of these men are called, but they are ready if an emergency should occur.

The operating sheets and sectionalizing diagrams do not preclude the need for a stand-by schedule. If all goes well a shutdown should be effected quickly and efficiently, but there is no guarantee that occasional difficulties will not arise. A large valve may stick or even break, necessitating the extension of the shutdown procedure to include the next section. This should be merely a matter of following the prescribed plan, but it is believed good practice to have someone in a supervisory capacity on the job at such times.

The operating sheets, however, do help the engineer, or anyone else in charge of a shutdown and diversion operation, because the best procedure has already been worked out and there is no time lost in tracing a pipeline on a map or copying down valve numbers and locations and then checking to see that some valve has not been overlooked. Such work can be done at leisure beforehand rather than under the tension accompanying a break. With or without a supervisor, however, the operating sheets save valuable time if a break occurs, when it can truly be said, "Time is of the essence." Furthermore, they can be adapted to the water department of any size city or town.

Reference

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Keeping Filters Clean

By R. W. Haywood Jr.

A paper presented on Nov. 18, 1947, at the Virginia Section Meeting, Roanoke, Va., by R. W. Haywood Jr., Asst. San. Engr., American Viscose Corp., Philadelphia.

THE satisfactory and economical operation of water filtration plants, whether the filters are of the gravity or pressure type, requires a full and comprehensive understanding of the subject of this paper. No other phase of water purification is more important in producing a filtered water with qualities acceptable to all and at the lowest cost. No one will disagree with these statements, yet filter maintenance is often considered a corrective step with resulting high costs and is undertaken only when conditions become so bad that there is no recourse but the adoption of "shotgun" tactics. It is much better to regard filter maintenance as a preventive measure to be carried on as a daily routine.

This paper proposes to discuss some of the points which must be kept in mind if a satisfactory preventive filter maintenance program is to be followed. These are: (1) preparation of water for filtering, (2) filter operation, (3) need for cleaning filters and (4) methods of cleaning.

Preparation of Water

The preparation of the water prior to putting it on the filters is one of the most important factors of all in keeping filters clean. "Preparation" means the application of the correct amounts of coagulant, adequate mixing and settling. Although these procedures may seem elementary, they are frequently slighted in many plants.

The proper dose of coagulant can be readily determined with a jar tester, a simple machine consisting of a number of motor-driven stirrers in a series of glass jars or beakers. By the use of standard solutions of coagulants, alkalies or acids, the best combination for treating the water at the time can be determined in a short while. The results should then be applied to the plant. The test is simple and easy to make, but to be of maximum value it should be made frequently.

Though the mixing and settling facilities of most plants may seem unalterable, they are not always so. After the proper chemical dosage is applied, the water should be watched. Does the floc form quickly in clearly defined particles? Does it settle rapidly and completely, leaving a clear water? Can short circuits be seen in the settling basins? If a sample of settled water is put back in the jar tester and stirred again, will more floc form? If it does, in all probability the mixing is not adequate and the possibility of increasing it—by additional baffles, by raising the speed of the mechanical mixers, or by the use of auxiliary mixing methods such as compressed air—should be considered. If the floc forms early in the mixing step and seems to break up, perhaps the agitation is too

violent or prolonged and should be decreased.

Short-circuiting of settling basins has the practical result of reducing the effective capacity of these units. The judicious use of baffles, either solid or perforated, will frequently result in a more even distribution of flow and in increased removal of suspended material from the coagulated water. It should be remembered that short circuits may occur in a vertical as well as a horizontal plane with the same result —less settling and a poorer quality of applied water.

What have these facts to do with filter maintenance? Simply this: a properly coagulated and settled water will impose the least possible load on a filter. Runs will be longer and there will be less tendency for the sand grains to become coated. Such water will have a minimum amount of coagulant remaining in solution. Fewer mud balls and hard spots will develop, and keeping the filter clean will be easier.

Filter Operation

The benefits to be derived from the most carefully prepared water will be lost if filters are not operated along common-sense lines. Since part of the filtered water must be used to wash the filters, the effective capacity of the plant is reduced by the total amount of water used, plus the time out of service for each unit which is being washed. In addition, the cost of the wash water must be considered. Enough water must therefore be used to keep the sand clean, but excessive amounts should be avoided since they only increase costs and decrease plant capacity. Good operation, then, means that the period of time between washings, or the duration of the run, should be as long as possible, but not so extended that excessive amounts of wash water are required to clean the filter.

It seems obvious that the best method to determine when a filter requires washing is to measure the amount of dirt it has removed. This is clearly shown by a loss-of-head indicator which is found on each filter in the majority of filter plants. Because the loss of head is a direct result of the amount of suspended matter caught by the filter, it indicates when the filter requires washing.

Another, and much less satisfactory, method is to wash each filter on a time schedule—that is, every 24 or 48 hours, or at some other predetermined interval. This method can only result in higher wash water requirements and the probability of filters being improperly cleaned.

How can it be determined if the filter is operating properly? Since its primary job is to remove suspended matter, the clarity of the filtered water is the first yardstick. Low turbidities mean good operation. A well-operated filter should produce filtered water that has a turbidity consistently below 0.2 ppm., and 0.1 ppm. is readily attainable. Anything higher should be looked on with suspicion.

Wash water requirements are another reliable indication of the effectiveness of the pretreatment and the condition of the filters. High wash water requirements can mean that the water has been improperly coagulated and settled or that the filters are dirty. A well-run plant should not require more than 2 per cent of the total water filtered for washing, and a great many plants operate on 1 per cent or less without the sacrifice of efficiency or quality.

Improper operating of filters presents an unmistakable picture. When the filter is in operation and is nearing the end of a run, one should walk

around the edge and look at the filter material carefully. Are there cracks across the surface or at the side by the walls? Is the surface uneven? Are there mounds at the edges where the level of the sand is higher than the rest? Any of these conditions indicates improper operation which has left undesirable quantities of mud, silt and floc in the filter.

Other red flags are waved during the washing of a filter. When the wash water is turned on, does the sand bed break up in large pieces, allowing the wash water to spurt through at a high velocity? If so, the sand is probably coated and tends to stick together to form a more solid mass than usual. After the filter has been washed until the surface of the sand is visible—and this is a wasteful practice—is there evidence that all the water is coming up through a small part of the total filter area, as indicated by the sand boiling violently in only a few spots and barely moving in others? Such a condition shows that either the wash water distribution system needs repair or so many hard spots have developed that the water has only a few passages through which it can flow.

Periodic examination of the sand will often show whether the washing procedure is correct. The filter should be drained and samples taken of sand at various depths. If the samples rubbed between the palms of the hands produce stains or mud, the sand is not being washed clean. The sand grains should be observed under a microscope, a magnifying glass or simply with the naked eye. If a coating can be seen, the washing procedure should be checked.

Need for Cleaning Filters

All too frequently, as long as a clear, palatable water is produced, the operator in charge feels that he and his plant are doing a good job. This may sometimes be true, but more definite indications are necessary to determine whether the filters have reached a state that requires special attention to return them to a clean and clear condition.

Obvious hard spots, mud balls and coated sand have been mentioned—these certainly are not compatible with a clean filter. High or constantly increasing wash water requirements should be a very plain sign that all is not well. High turbidity in the filtered water tells the same story, and, in municipal plants where bacteriological analyses are made, higher bacterial counts in the filtered water than in the applied water point to dirty units. If prechlorination is used, an increasing depletion of residual chlorine in the water as it passes through the filter also adds evidence that something is wrong. Eventually, from one cause or another, the fact becomes inescapable that all is not well and steps must be taken to clean the filter.

Cleaning Methods

During normal operation the filters have been washed periodically. Why, then, are they dirty? Examination of the reason for washing, together with the mechanics of washing and deviations from the most accepted methods, should give the answer.

The purpose of washing is obviously to remove the dirt from the sand grains and from the pores or spaces between them. If the filters are not washed, they eventually become so plugged that the water can no longer penetrate them, and they cease to function. As the mud accumulates, the sand grains are "cemented" together, and, unless these accumulations are broken up, the plugged portion of the filter will remain inactive.

thus reducing its capacity, since no water can pass through the solid area. The washing, therefore, is intended to remove accumulated mud from the filter and the sand grains and to prevent hard spots and mud balls from forming.

Two separate actions take place during the washing period: (1) The sand particles are scrubbed both by the friction of the water as it passes through and by rubbing against one another. (2) The loose mud and portions of coating that are scoured from the sand are then lifted out of the filter by the upward velocity of the wash water.

To accomplish these results, the wash is divided into two equally important parts. Improper starting of the wash can do damage which will eventually require that the entire filter be rebuilt. Too short a second period will leave the filter dirty, and too long a period will waste wash water.

It has already been mentioned that at the very beginning of the wash the sand tends to break up into large masses. This is true with clean sand but even more so when the sand is dirty. If the wash water is turned on at any but the lowest rate, pressure will develop under the sand and, as soon as these large masses move, will be relieved by the water spurting up through the cracks that result. Moving at a high velocity, the water will carry the fine gravel into the sand and the arrangement of sand and gravel will be seriously disturbed. Therefore, it is of the utmost importance that washing be started very slowly and that from two to four minutes be allowed for the sand bed to become fluid.

The first period should continue for possibly ten minutes at a low rate—just enough to keep the material fluid and the sand grains churning and striking each other. During this time accumulated coating is removed much more efficiently than if the full velocity of waste water is turned on, because under full rate of wash the grains are separated from each other by a cushion of water and the scouring action of grain against grain is decreased.

The second period of wash is at the high rate and serves to flush out the mud and accumulated solids. This step is frequently carried too far and excessive wash water use results. At the beginning of the high rate wash, solids are carried in large quantities per unit of wash water. Assuming that each gallon at the start of this period will remove 100 particles, as the wash progresses the figure soon falls to 50 particles per gallon, then to 25 and so on. Obviously, the point is eventually reached at which the amount of solids removed per gallon of wash water is too small to make continued washing economical. Experience indicates that, in many plants, if a filter is washed until the sand is visible, the washing has been overdone. It is suggested that some reference point—say, 1 ft. below the surface of the water in the filter—be selected and the wash stopped when this point can be seen.

Often the rate of wash is insufficient to permit the removal of all the larger particles. In recent years auxiliary washing devices have been developed and are doing an excellent job in keeping the filter clean by breaking up these agglomerated solids as well as mud balls and hard spots. Perhaps the best-known of these devices is the Palmer sweep consisting of a horizontally rotating hollow arm from which jets of water strike the sand particles at high velocities and greatly increase the scouring and breaking action. Other equipment serving the same purpose is available.

If hard spots are found, or seem to be developing, it is frequently necessary

either to remove them by digging them out or to break them up manually. When the filter is being washed and the filter material is fluid, these spots can be found by probing with a long pole, which can then be used to break them apart. Many different kinds of "poles" have been developed—some with cross arms, others with a gridwork on the end and some driven by an electric drill. They all serve the same purpose; that is, to break up the hard spots sufficiently for the wash water to get through them and hasten their elimination. This is frequently a long and tiresome job, the only alternative being actually to dig them out and replace them with fresh sand.

Some types of coatings on sand respond to chemical treatment, but care should be used in selecting and applying the proper chemical. Coatings composed primarily of accumulated alum floc, silt and mud will frequently respond to heavy doses of caustic soda. If organic material is present, the addition of chlorine with the caustic soda may prove advantageous. When the coating is predominantly organic in nature, as in treating highly colored waters, it may be removed with sulfur dioxide. Some waters contain iron and manganese to such an extent that the sand grains turn black and begin to look like mustard seed. This may also be treated by sulfur dioxide. The point to be stressed is that no one chemical will satisfactorily cope with all forms of coatings and some thought and knowledge is required in selecting the proper one. Details of the various treatments are readily available in the literature and are purposely omitted here.

One word of caution—chemicals used to clean the sand and remove mud balls and hard spots, it must be remembered, will have little effect on the latter unless the cleaning solution enters the portions of the sand that are stuck together. It is therefore necessary that such accumulations be broken open. If this step is not taken, the uncemented filter sand may be cleaned but the hard spots will not be materially affected.

Records

This paper would not be complete if proper emphasis were not laid on the keeping of records. No matter how carefully and conscientiously a plant is operated, unless records are kept, today's experiences are forgotten tomorrow. Records of the character of the water—such as the turbidity, alkalinity and pH—together with records of chemical doses, form a valuable background for knowing what to expect during certain periods of the year. Records of the length of filter runs for each unit will indicate whether any particular unit is getting out of line. Wash water records show the efficiency of plant operation and should include both the volume used and the per cent of filtered water. The latter figure is one of the most indicative of all in filter plant operation. Other data may seem desirable to the individual operator, but the important thing is to keep written records and use them.

Details have deliberately been omitted from this article because each plant is a law unto itself and specific procedures must be worked out locally. It is hoped that some of the ideas presented will be of interest and will assist in keeping filters clean.

Selection of Deep Well Pumps

By A. O. Fabrin

A paper presented on Oct. 15, 1947, at the Southwest Section Meeting, Amarillo, Tex., by A. O. Fabrin, Chief Engr., Layne and Bowler, Inc., Memphis, Tenn.

DELIBERATE violations of streamline design in pump passages are the causes of many troubles incidental to corrosion. The deep well centrifugal pump made of iron, steel and bronze is used to pump water that naturally contains varying quantities of dissolved oxygen. It is true that well water may, in its essentially static state in the ground, contain practically no free oxygen because the rain or surface water—which enters at the outcrop, sinks into the earth and travels through various strata toward the static water level—has yielded up free or dissolved oxygen. If there is a small amount of free oxygen in the water, however, the hydrogen film protecting the metal surfaces of a pump body may be oxidized and the corrosion rate accelerated. If no free or dissolved oxygen is present, but oxygen-yielding nitrates are, the corrosive rate also will be accelerated.

In a centrifugal pump the impellers, because of changing pressure and velocity, serve as mechanical agitators, facilitating the liberation of gases so destructive in corrosive activities. It would seem, therefore, that the primary stage of corrosion, or the requisites for corrosion, are chemical in nature.

Absolutely pure water cannot be found on the surface or underground, but only in the laboratory as a result of distilling ordinary water. Rain water containing dissolved oxygen acts upon the organic and mineral matter in the earth strata. Consequently, a chemical change is realized, resulting in water solutions of salts, acids, alkalies or bases.

Water solutions as described are most important when electrochemical phenomena are applied to the problem of corrosion. In studying the corrosion of ferrous metals it is necessary to consider the composition of the alloy, the protective coating used, if any, the individual circumstances concerning the application of the metal and the nature of the water encountered.

In the last few years the common form of cast iron has given way to iron alloys having varying amounts of chromium, nickel or copper. These ferrous alloys are sold under different trade names, but in essence their composition has gradually become standardized and their merits and uses can be ascertained from standard handbooks of recent publication.

Electrolytic Corrosion

A continued study of the destruction of iron makes mandatory a consideration of water passage design. Too often the blame for a used pump beyond repair is laid to electrolysis, a

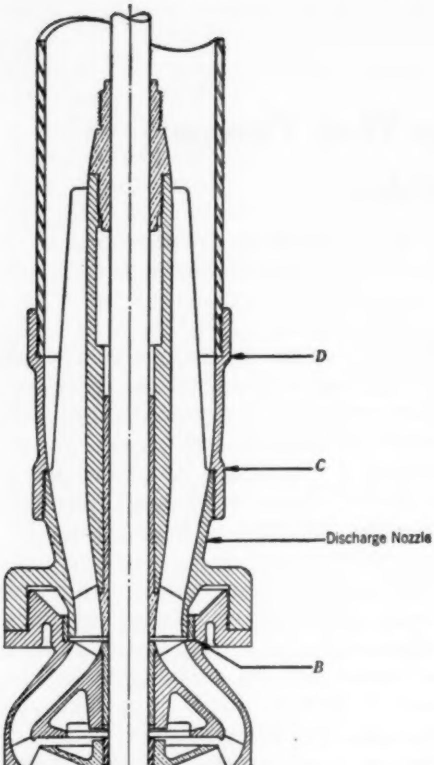

FIG. 1. Typical Cross Section of Deep Well Centrifugal Pump

word which covers a multitude of sins. The yearly loss due to the corrosion of pipelines amounts to over $25,000,000, a large part of which can be attributed to electrolysis. Electrolysis also plays an important part when a lead sheath surrounds a buried cable. It has been found that 1 amp. flowing steadily for one year will carry into solution 74 lb. of lead.

The conditions under which electrolytic action takes place in the two examples cited are not those existing in the interior of a pump. A buried pipeline or a lead-sheathed cable reposes in a physically dormant medium. There is no flowing water on the outside of either; the metal is being removed from the positively charged conduits and deposited in the negatively charged soil. This is electrolysis and is not to be confused with the galvanic action encountered with an electrolyte and electrodes.

Galvanic Corrosion

Galvanic corrosion is caused by the deliberate or accidental use of dissimilar metals in contact with each other in the presence of an electrolyte, which commonly is water. The rate of such corrosion is progressively enhanced by: (1) higher concentrations of minerals and gases in the water, (2) a higher surface area ratio of one metal—such as bronze—to a dissimilar one—such as iron or steel—above it in the emf. series, (3) higher rates of water-flow past the metal surface, (4) a lesser distance (lesser resistance to current flow) between the two metals at the metal–water–metal portion of the circuit. Factor (4) is limited by polarization when in very close proximity and by the accumulation of corrosion products.

Pump Design a Corrosion Factor

Seemingly paradoxical situations sometimes arise in which two different types of pumps, made by the same factory from the same materials and operating under the same conditions, show varying degrees of deterioration. The deeper one goes into the subject of pump corrosion, the more convincing is the evidence against improper water passage contours as a cause of corrosion. The investigator is struck by the singular fact that not all of the portions of the pump with changing contours corrode uniformly. Impeller vanes and the stationary vanes in the bowl may not corrode as rapidly as the suction and discharge nozzles of a pump. This condition indicates that correct hydraulic principles have been followed in the major design. Furthermore, the realization of competitive efficiencies is also proof that impeller and diffuser design are correct in principle.

The principles of correct design are predicated upon the collection of empirical data derived from numerous tests. One principle which governs the efficient handling of velocity in a water stream concerns the rate of positive and negative acceleration.

Because the suction and discharge nozzles (Fig. 1) are not moving parts but are considered merely as conduits, enough thought has not been given to their hydraulic proportions; rather the economic factor has been the predominant motive affecting the design.

Naturally, the shorter the suction and discharge nozzle, the cheaper will be the castings. Shorter stainless-steel impeller shafts can also be used, thereby bringing the manufacturing cost down. The principle governing the rate of acceleration should determine the length of suction and discharge nozzles. If for manufacturing economy the nozzles are too short, the metal contours do not parallel the natural streamline boundaries of the flowing water. The proper angle of divergence for a cone carrying a fluid undergoing negative acceleration is very nearly 5 deg. 6 minutes. When a second member is placed in the cone, the angle can be increased to 12 deg. If in designing the nozzle the angle of divergence is made greater than 12 deg., it means that between the flow line boundary and the metal contour there will be whirls or eddies which favor the erosion, or corrosion, of the discharge nozzle.

Fortunately, the positive acceleration of water as encountered in the suction nozzle does not present so delicate a problem as the negative acceleration in the discharge nozzle. Eddy currents are not so easily produced in a converging tube. For this reason the angle of convergence in the suction nozzle can be greater than the angle of divergence in the discharge nozzle.

Violations of stream flow design are not the only reasons for the presence of whirls and eddies, which may be caused by a valve, a fitting, a tee, a sudden change in diameter or a protruding shoulder.

Dissolved gases, as is known, are readily liberated in an eddy and are not easily reabsorbed in the flow of water. These liberated gases have greater corrosive action than pure air. A good example of corrosion because of eddy formation is seen at the pipe connection on both the suction and discharge nozzles of pumps. Careful junctions with matched diameters at joints *A, B, C* and *D* shown in Fig. 1, together with strict attention to the converging and diverging pump parts, will prevent much of the cor-

rosion trouble at suction and discharge connections.

A motive, aside from the corrosion factor, favoring more care in connection design is the possibility of an increase in efficiency when proper conical sections are used. A practical demonstration of the efficiency realized in proper converging and diverging tubes is the Venturi meter.

A centrifugal deep well pump can be compared, after a fashion, with the Venturi. The pump suction nozzle is similar to the converging inlet of the Venturi; the impellers handling high velocity water match the restricted throat of the Venturi; and the pump discharge nozzle parallels the long diverging outlet tube of the Venturi.

In summarizing all of the foregoing, these conclusions may be listed:

1. If a well is constructed so that there is a cascade of water down to the pumping level, a copious supply of free oxygen will be entrained in the water, and if, in connection with this, the pump suction is not deeply submerged, there is danger of a high corrosion rate. Pump submergence should be kept as great as possible to minimize corrosion.

2. Although galvanic action may be regarded as a plausible explanation for the corrosion of cast iron opposite the impeller wear-ring skirt, it alone does not explain the occasional occurrence of holes in the wall of the bowl section. The highly misused general term electrolysis is also an inconceivable excuse for corrosion at this point. The likely cause is the presence of eddies, which provide local points of high velocity and changing pressure within the general stream flow. Improving the design of pumps to decrease the amount and intensity of eddy formation can reduce this occurrence of corrosion.

Improved design at the suction and discharge pipe connections to the cast-iron bowls can also reduce the eddy formation and velocity factor at these points, whether bronze is present as a factor or not.

Wherever possible, compatible metals should be chosen in pump construction. Such metals have potential values and polarization properties that make them not too divergent (incompatible) in the electromotive scale. The modern use of stainless-steel impeller shafts with bronze impellers and bushings has eliminated the former severe corrosion of impeller shafts which were of ordinary steel.

3. Pump life and frequency of repairs should be checked against the analysis of the water and the possibility of a change in the analysis with varying pumping levels should be investigated.

There are many other conditions which have an important bearing on corrosion, but it is believed that sincere attention to the three mentioned will shed some light on the corrosion problem encountered in the suction and discharge castings and in the joint where the suction and column pipes connect these parts to the pump.

Erosion of Case Vane Ends

The impeller and that portion of the pump case immediately surrounding the impeller have been compared with the restricted throat of the Venturi meter. Since, as in the Venturi throat, the velocity will be high at this station in the pump, careful handling of the water stream is important.

Most deep well pump manufacturers have accepted as axiomatic a design in which the stationary vanes in the

pump case extend down so far that the vane ends are close to the moving impeller's periphery. Excellent efficiencies are developed by pumps of this typical design. If, however, comparable efficiencies could be developed by using a design in which the rapidly moving water from the impeller would not impinge directly upon closely adjacent stationary vane ends, this design would be worthy of consideration. Before evidence is submitted to support the claim that such designs are competitive, some aspects of the erosion of case vane ends should be considered.

In the author's opinion, the amount of carbon dioxide in ground water is a factor in the corrosion rate in deep well centrifugal pumps. Although other gases are destructive to a greater degree than carbon dioxide, the latter is more commonly present. It causes graphitic corrosion, the effects of which on a cast-iron body are well known: the metal loses its strength and can be whittled with a pocketknife.

After the work of carbon dioxide has been completed, the vane ends adjacent to the impeller become vulnerable and in time are destroyed or at least so multilated by the impinging water stream from the impeller that satisfactory water guidance is gone. Because the destruction may not be uniform, there is the possibility of eccentric loading or reaction on the impeller. When this occurs the pump bearing may be pounded and worn elliptical.

This is the beginning of mechanical trouble, for another serious condition now arises to plague the machine. The eccentric loading of the impeller is conducive to eddy formation, and the non-uniformly deteriorated vane ends will induce further eddies. It is indeed illogical for anyone to doubt the presence of eddies, and even though the sequence of destruction, the order in which it occurs or the manner in which it has been treated may not be fully and completely accepted, scientific reasoning permits no denial that the closely adjacent vanes are ideal for eddy formation. No one is better fitted to explain these phenomena than Professor A. H. Gibson of the University of Manchester, England. According to Gibson (1), the viscous forces of water are proportional to velocity; and inertia, to velocity squared. The relative value of the former forces becomes less as the velocity becomes greater. At low velocities the stabilizing effect of viscosity is of great importance and any tendency to depart from streamline motion, such as may be caused by roughness of surface, is checked without producing eddies. As the speed becomes greater, the inertia forces become so relatively large that, at some velocity, viscosity is no longer able to prevent departure from streamline flow, and any surface irregularities cause rapidly rotating particles of fluid to be projected from the surface to form eddy nuclei. Attention is called to Fig. 2 which illustrates the condition of affairs in a conventional pump case. The stationary vanes in the casting extend as far down as, and immediately adjacent to, the impeller outlet. If the velocity of the water issuing from the impeller is low enough to complement the Reynolds number, the stabilizing effect of viscosity will overcome the tendency to produce eddies.

But the velocity of flow at this station of the pump is never sufficiently low to cause a true laminar flow, and the intercepting vanes may impose

upon the conditions of flow the same deleterious effects as the roughness of the surface in a pipe or conduit. This is particularly true if the vane design is not hydraulically correct, but if the angle of obliquity is correct the absolute velocity of the water leaving the impeller will be properly associated with the velocity permitted by the stationary case vanes. In general, it can be said that this feature of hydraulic design is accurate in most deep well pumps on the market.

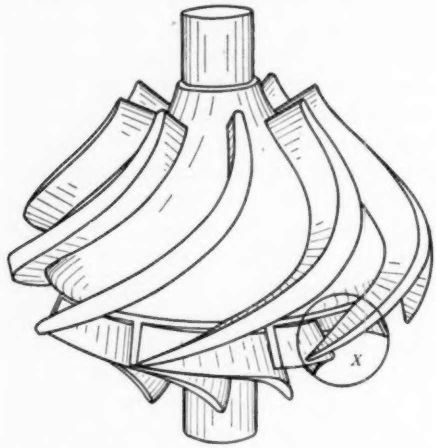

Fig. 2. Conventional Deep Well Centrifugal Pump Case and Impeller

Numerous laboratory tests leave no doubt that high efficiencies are obtained on pumps with case vanes that extend down to the impeller exit. But if the nature of the water is such that the relatively thin vane edges will deteriorate, then the actual performance of the pump will fall shy of laboratory performance.

There would be no object in suggesting a change in design if all the various departments concerned with manufacture, test and application were not mutually benefited. For example, no benefit would accrue to the owner of a well and pump having "free flow" pump cases if the water contained no corrosive agents. This would be particularly true if "free flow" pump cases were associated with lower efficiency, although fortunately they are not.

Hydraulic Performance of "Free Flow" Pumps

In discussing the hydraulic performance of "free flow" pump cases, a comparison may be made between the hydraulic conditions at the exit

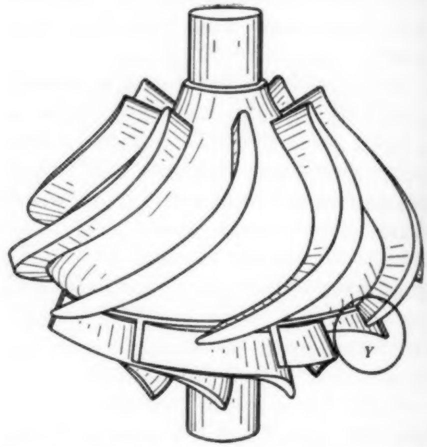

Fig. 3. "Free Flow" Deep Well Centrifugal Pump Case and Impeller

from a pump impeller and those which exist at the outflow from a water turbine runner. In 1921 Moody (2) stated: "The outflow loss from a runner is not necessarily dependent upon directions of loss, since the whirl component is as efficiently handled in the draft tube as the meridian flow."

If this is true in water turbine design why not apply the principle to a deep well centrifugal pump case, which is concentric and not of the volute type, thus lending itself admirably to whirl chamber design? Figure 3 illustrates this type of pump case

with a whirl chamber. As can be seen at *Y*, no vanes extend down to the periphery of the impeller. This is comparable with the draft tube at the point of exit from the water turbine runner.

The author would most certainly agree with the comment that such a design is not new, inasmuch as he executed the so-called "free flow" design over twenty years ago. At that time, however, work was confined to pumps of high specific speed, as low-specific-speed pumps were not in demand. Today the commercial demand for deep well pumps extends over the whole band of the specific-speed range usually associated with well work.

At present, developments have reached a stage where it may be safely stated that "free flow" cases can be used on any deep well pump within the specific-speed range of 1,500–4,200 N_s.* There have been special occasions where the specific-speed range was expanded to include 1,300–5,000 N_s.

To support the foregoing statements, the chart in Fig. 4 is presented, showing the performance characteristics of two different "iso-vane" impellers in identical "free flow" pump cases (no enamel). Note that competitive efficiencies are developed by this particular 10-in. pump with "free flow" pump cases. It will also be observed that both high- and low-capacity impellers cover a wide capacity range with no sacrifice in efficiency.

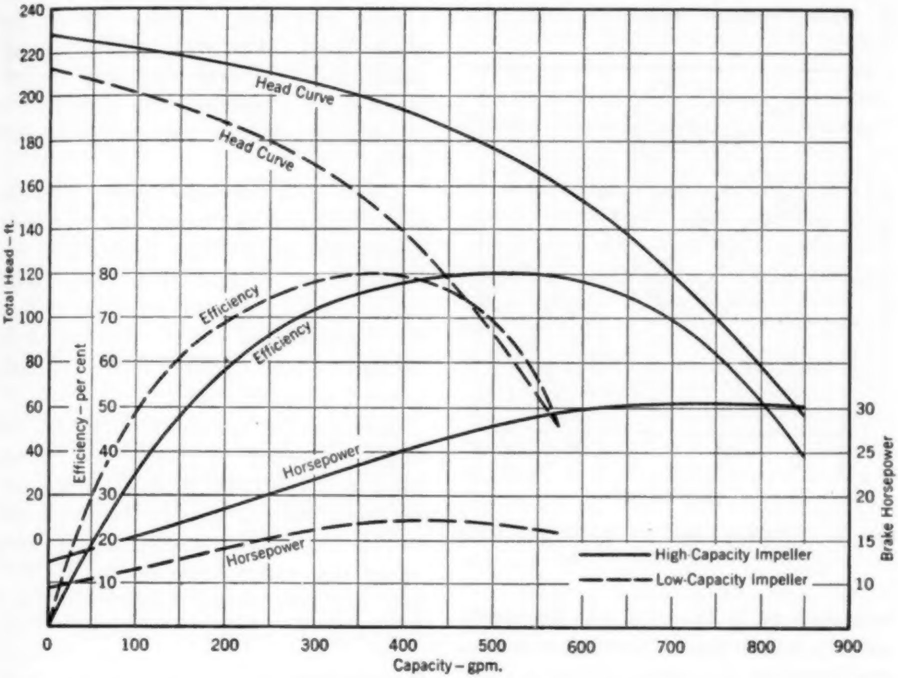

FIG. 4. Performance Characteristics of Two Impellers in Identical "Free Flow" Pump Cases

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* N_s, or specific speed, is a relationship among three variables: pump capacity (gpm.), head per stage (ft.) and speed of rotation (rpm.) (3).

Because such pumps lend themselves very well to impeller diameter variation, they can often be utilized where the total discharge head lies between values developed by several full-diameter impellers.

Figure 4 applies to a pump case which is good for peak efficiencies at 350–525 gpm. For greater or lesser capacities different pump cases must be considered. For instance, a series of 10-in. pumps handling capacities

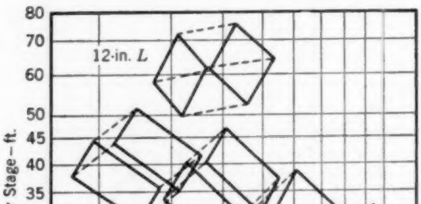

FIG. 5. Selection Chart for 1,750-rpm. Deep Well Centrifugal Pumps

from 175 to 1,200 gpm. can be developed in which four different cases are used to cover the range. Two or three impellers can be fitted in each case, and with impeller diameter variation such an arrangement will result in a rating chart as shown in Fig. 5.

Each case, fitted with impellers as described, is represented in the chart by a cube and gives an impression of length, breadth and thickness. To indicate the manner in which such a chart could blanket a large field of pump requirements, it is necessary only to observe the way a 12-in. small-capacity case fits into its position above the 10-in. group. Three more 12-in. cases resembling cubes could be delineated above the 10-in. figures.

Conclusions

"Free flow" pump cases tend to alleviate corrosion troubles within the pump bowl. The wide capacity range obtained by several impellers in one identical case permits the substitution of impellers to suit the change in well yield.

Clean and smooth pump interiors are of prime importance, and an expert knowledge of foundry practice is not required to see that "free flow" bowl vanes are shorter and more direct than the conventional vanes. In Fig. 3, *Y* illustrates the direct flow channels formed by such vanes.

For specific speeds of 1,500 N_s the angle of sweep of "free flow" vanes need not be more than 70 deg., and for high specific speeds the angle can be 45 deg. With conventional pump cases the vanes may sweep 160–180 deg. and this means delicate cores and difficulty in cleaning castings.

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Design Features of the Northeast Station Reservoir

By Leo V. Garrity

A paper presented on Sept. 19, 1947, at the Michigan Section Meeting, Bay City, Mich., by Leo V. Garrity, Asst. Gen. Supt., Dept. of Water Supply, Detroit.

It is estimated that the Detroit Dept. of Water Supply serves between 2,300,000 and 2,400,000 people at present. From studies made by this department and by local utilities and agencies whose operations require sound forecasts, it is now believed that the population connected will reach 3,000,000 by the year 1970. Analyses of the demands on the works over the past 32 years have led to the conclusion that the values which may safely be used in future design for the expansion of the system as a whole are: a consumption of 140 gpd. per capita, a ratio of maximum day to average day consumption of 1.55 and a ratio of maximum hour to average day consumption of 2.70.

From these data and the foregoing population forecast, the entire system must be in a position to meet a maximum hour rate of 1,134 mgd. and a maximum day demand of 650 mgd. by the year 1970.

With existing facilities, including the Modern Avenue Booster Station, it is possible to deliver water to the system at the rate of about 880 mgd. and maintain a minimum pressure of 30 psi. at the city limits. On August 6, 1947, the existing stations pumped water into the system at the rate of 876 mgd. between 6:00 and 7:00 P.M., when an all-time maximum day and maximum hour demand was experienced.

The present facilities at the Water Works Park Station are capable of meeting a maximum hour demand rate of 409 mgd. at the required station pressures, provided the demand develops in its area. By increasing the filtered water reservoir capacity and the capacity of the high-lift pumps at the Springwells Station it will be possible to increase the maximum hour rate at that station to 450 mgd. With the present and expanded facilities, the two stations will be in a position to meet a maximum hour demand at the rate of about 860 mgd., leaving 274 mgd. to be made up at a new station.

Assuming a maximum hour rate of 274 mgd., the corresponding maximum and average daily output at the new station will be 158 and 102 mgd., respectively, using the foregoing ratios. The theoretical net reservoir capacity required to equalize the filter production on the maximum day is 24.5 mil.gal. The capacity of the reservoir selected is 30 mil.gal. net, which will allow sufficient freeboard to follow safely the vagaries of the actual load should it develop characteristics unlike those predicted at present.

As now planned, the new station, to be built on a 62-acre site at Eight

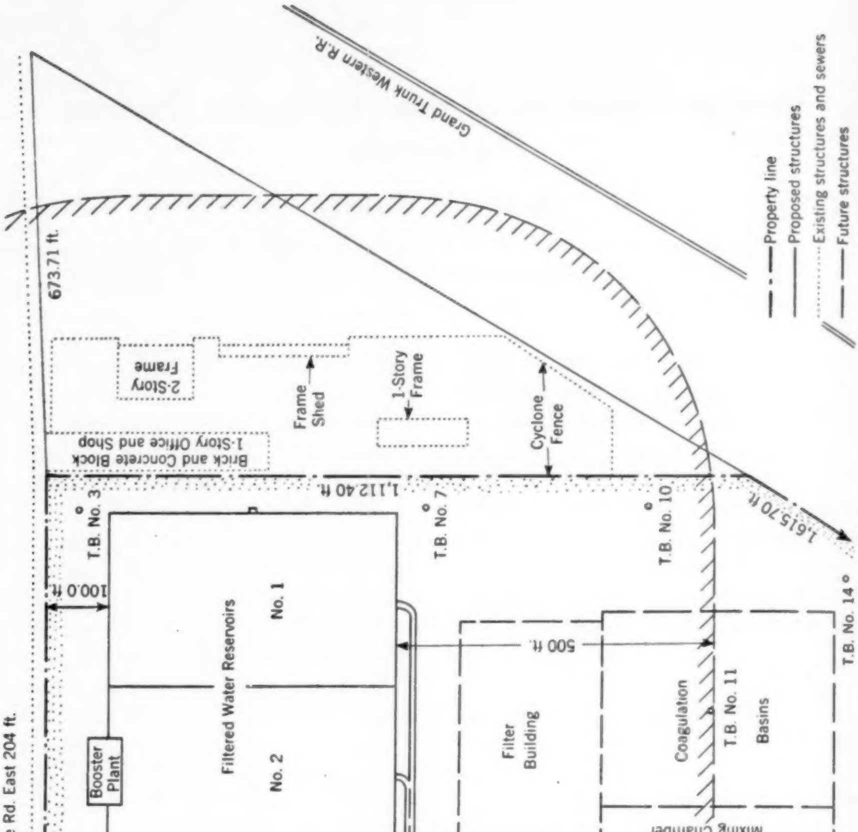

FIG. 1. Northeast Station Site

Mile Road and the Grand Trunk Railroad, will treat raw Detroit River water completely and will include flocculators, coagulation and sedimentation basins, rapid sand filters, high- and low-lift pumps, chlorinators and a complete power plant (Fig. 1). The raw water will reach the plant through a tunnel driven from a connection to the existing junction works at Pennsylvania and Forest Avenues. This tunnel will be 10 ft. in diameter and about 5½ miles in length and will average approximately 85 ft. in depth.

It is planned to proceed with the construction of the Northeast Station and the expansion at the Springwells Station, to provide the needed facilities as the demand develops and finances permit. In the meantime a contract has been let and construction is now under way for the 30-mil.gal. reservoir structure and a temporary booster station. The temporary works, when completed, will serve in the interim as a peak-load station. The reservoir will be filled from either Water Works Park or Springwells Station, or both, during off-peak hours, and water will be pumped from the reservoir into the system during periods of maximum demand.

The temporary booster station will house four electrically driven centrifugal pumps, each rated at 40 mgd. against a total dynamic head of 175 ft. Three of these pumps will be moved from the present Modern Avenue Booster Station, upon which the Water Department's lease will expire on June 15, 1949. It is expected that the new booster station will be ready for operation by that date.

Soil Investigations

A total of fourteen test borings were put down on the site (shown in Fig. 1 by T.B. No. 1, etc.) before the design for the reservoir was started. Samples of the soil were taken at depth intervals of 5 ft. in each hole and wherever the ground changed. Transverse shearing resistance tests (1) were run on these samples and the soil constants and particle size distribution determined. All of the tests were performed in the Soils Mechanics Laboratory of the Dept. of Engineering Research of the University of Michigan. A composite log and analysis of the borings pertinent to the reservoir site are shown in Fig. 2. From the data thus obtained, determinations were made of the safe bearing capacity of the soil, the embankment slopes required to insure stability during construction, and the boundaries of the area adjacent to the construction upon which superimposed loading would have to be limited to protect the excavation against upheavals and slides.

With the reservoir full, the average pressure on the soil will be 1,740 psf. and the highest intensity, 2,250 psf., will occur under the wall footings. The average pressure on the soil when the reservoir is empty will be 650 psf. Investigation shows that with these conditions of loading the intensities are well within the safe bearing capacity of the soil and that the reservoir, when empty, will be safe against uplift from soil pressure. It is to be noted that the reservoir structure weighs less than the soil it displaces.

The history of heavy excavations in the clay soils in the Detroit area is fraught with descriptions of serious and costly slides and upheavals attributable to improper slopes and overloading of the adjacent banks. From analyses of the soil samples obtained from the borings it was determined that if the slopes were cut steeper than

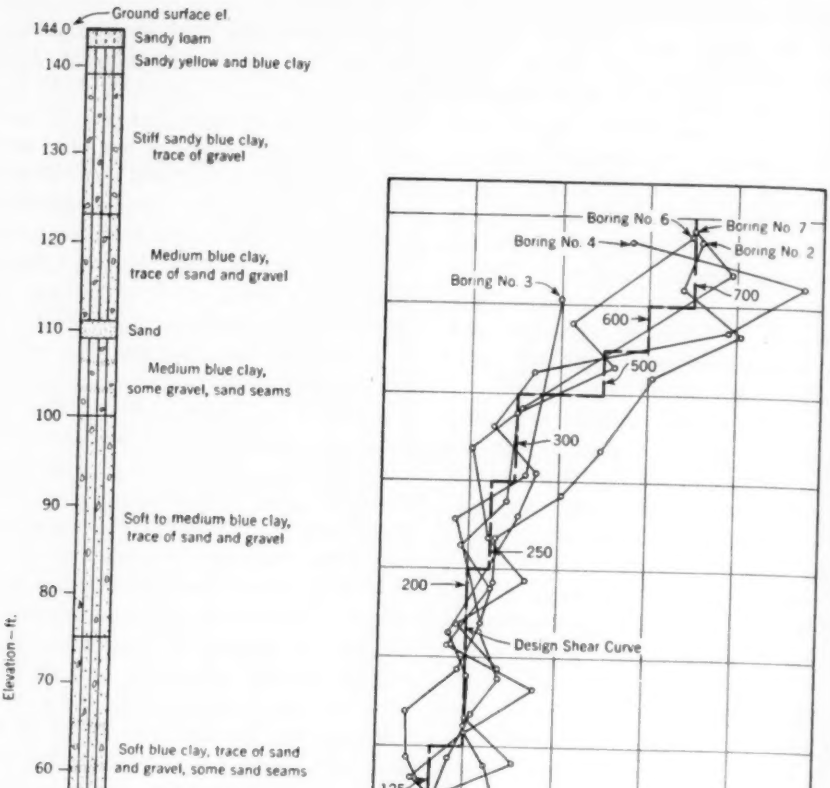

FIG. 2. Soil Profile and Analysis of Borings

one vertical to two horizontal, significant earth movements were likely to occur during the construction period. Accordingly, this limiting ratio was made a part of the contract.

Analysis further indicated that the heavy superimposed loads likely to be brought on the soil by spoil and from concrete aggregate stockpiles should be kept a distance of 415 ft. from the excavation (1). The contract, therefore, prohibits the storing of excavated materials and concrete aggregate stockpiles within 500 ft. of the reservoir structure, and the prohibited area is marked by hatching on the contract drawings, as in Fig. 1.

Reservoir Structure Design

The information obtained from the site borings and their subsequent analyses called for a reinforced concrete structure. Three types were considered in the preliminary design studies: rigid frame, "slab band" and flat slab. The use of piling was suggested, primarily for anchorage against flotation in case of failure of the underdrainage system, and for the footings in the rigid frame studies. It was concluded that the most economical design should employ two-way flat-slab construction for the roof and base slabs with the side walls designed as fixed-end vertical slabs between them, and that advantage should be taken of the bearing capacity of the soil to omit piling.

To protect the structure against flotation if the underdrainage system should fail, 206 pressure-relief valves are provided for installation in the base slab (Fig. 3). These valves are designed to open when the differential head of water—ground water level to reservoir level—is 4 ft. less than that required to float the structure. They will serve, as well, during the construction period before the drainage system can be placed in operation. Considering the nature of the soil and the underdrainage system provided, it is unlikely that these valves will ever be called upon to function, but they provide excellent insurance at a relatively low cost. It is estimated that anchor piles serving the same purpose would have cost $343,000, while the valves, installed, will cost less than $10,000.

The department has four flat-slab reservoirs in service with a total gross capacity of 100 mil.gal., the oldest having been completed in 1923 and the most recent in 1931. Observation of these structures and an approximate analysis of the flat slab as an elastic frame led to the conclusion that the recommended American Coefficients (2, 3) do not yield a satisfactory design for underground flat-slab reservoirs.

It is appreciated that designs based upon these coefficients have been quite successful in multiple-story construction where the more or less continuous columns may have a profound effect on stress distribution. It may be dangerous, however, to extend this experience to single-story underground structures. Then, too, as far as can be determined, proper cognizance of steel stress relief due to tension in the concrete may not be reflected in the American Coefficients. G. P. Manning (4), an Englishman, states:

> American Standards for design of flat slabs do not result in the same factor of safety as results for slab and girder floors. American Moment Coefficients are based largely upon observed stresses in steel reinforcement under working load or test load which lead to false values for moments since [the] tensile strength of uncracked concrete has relieved or reduced the steel tension.

The coefficients proposed by Manning, which yield results more in line with those obtained from an analysis of the structure as a continuous frame, were adopted for the design of the reservoir flat slabs and are shown herewith:

1. Total Moment: $0.896 \frac{WL}{8}$
2. Column Strip, Positive: $\frac{WL}{30}$
3. Column Strip, Negative: $\frac{WL}{22}$
4. Middle Strip, Positive: $\frac{WL}{60}$
5. Middle Strip, Negative: $\frac{WL}{60}$.

L is the center-to-center distance between columns and W is the total live and dead load, in pounds, on one panel.

Using the foregoing coefficients, the total moment will be 179, the concrete thickness 115 and the column strip positive moment 267 per cent of the values obtained by following the Recommended American Practice. From observations made of the reservoir structures in service it is concluded that they lack stiffness and show signs of weakness in the areas of positive moment in the column strips. The above values, therefore, seem to be increased in the right direction.

The exterior vertical walls were designed as fixed-end slabs to resist the internal hydrostatic pressure without assistance from the earth and an external earth load, using 75 lb. per cubic foot equivalent liquid pressure, with the reservoir empty.

The exterior bays of the structure were analyzed as continuous frames, taking into account the loads on the roof slab, base slab and walls; six combinations of loading were used to produce maximum stresses at the joints and at mid-span.

Concrete Quality

Needless to say, the quality of the concrete in the structure can affect the success of the completed work to the same degree, at least, as the quality of the structural design. Valuable information on the control of concrete is available in the numerous and excellent publications of the Portland Cement Assn. Quoting, in part, from one of these (5):

> The design of concrete mixtures is based principally upon the relationship, established by extensive research, between the properties of the hardened concrete and the amount of mixing water used. By these extensive investigations in both laboratory and field, a fundamental law has been established which may be stated as follows: For plastic mixtures, using sound aggregates, the strength and other desirable properties of concrete under given job conditions are governed by the net quantity of mixing water used per sack of cement. . . . It should be noted that in the statement of the water-cement ratio law above, its application is limited to *plastic mixtures* and given *job conditions*. In the laboratory studies leading to the discovery of this principle it was found that, unless the mixtures were of such consistency [that] they could be readily molded into a dense, compact mass, the strength results did not conform to the general relationship. Likewise, in the studies of watertightness it was found that, unless the mixtures were easily placeable and at the same time not so fluid as to segregate in placing, no regular relationship existed between watertightness and quantity of mixing water. The need for this plastic consistency during construction is just as important as in the laboratory studies if the concrete in the structure is to have the properties for

which it is being designed. This is particularly true in respect to watertightness. Not only must the quality of the paste (determined by the water-cement ratio) be such as to give impermeability, but the quantity of the paste must be such that true plasticity results. True plasticity means neither too wet nor too dry. Overwet mixes segregate in handling and those that are too dry cannot be properly compacted.

This quotation is a clear exposition of the fundamental qualitative basis for the design of concrete mixtures, and it is to be observed how the fact that the so-called water–cement ratio law holds only for plastic mixtures is stressed. The importance of plasticity in concrete mixes suggested that a more rational approach to their design and control would result if that necessary characteristic were better understood. Accordingly, an investigation was made during the period 1936–41 into the mechanics of concrete mixtures, and the results have been applied to the design and control of all such mixes subsequently used. A summary of these results is given in this article to furnish information on the background of the specific concrete mix requirements included in the Northeast Station Reservoir contract.

If the fracture planes of concrete compressive strength specimens are examined after tests, it is found that the mortar tends to envelop, with strong bond, the coarse aggregate particles in concretes of low water content. On the other hand, there is a lack of bond on the bottom (as poured) and sides of the coarse aggregate particles in the low-strength, high-water-content concretes, and in the extremely wet mixes there is an almost complete absence of bond except on the top surfaces of the coarse aggregates.

Experiments in wet mixes show that because the heavier coarse aggregate particles settle at a higher rate than the cement-carrying matrix—and consequently reach their final position of rest in advance of the mortar—favorable deposition of the cementing medium obtains on the top of these particles, with a lack of intimate bond between the mortar and the underside. Observation of the behavior of wet mixes leads to the conclusion there are at least three internal forces at work in mortar, as well as concrete mixtures, which resist or tend to resist displacement or flow: (1) cohesion, (2) particle friction and (3) particle interlocking.

Of these three forces, cohesion is the most important and must predominate if the potential strength of the mixture is developed. As here used, cohesion defines that property of the mixture which resists displacement by forces of molecular origin between the fine particles; the term includes adhesion, as usually defined, as well as true cohesion. The seat of cohesion lies in the molecular forces acting between the finest particles in the mix (of highest magnitude in the microscopic and submicroscopic sizes) and their moisture films. Water molecules are bipolar and therefore have the ability to orient themselves at the water-particle surface interface, minus to plus or plus to minus, depending upon the signs of the charges on the particle surfaces. It is now believed the molecules in the surface layer are positively attached and in this absorbed film lose the properties and characteristics possessed by free molecules in the true liquid state in the body of the fluid. As water is supplied to swell the films, orientation of the molecules continues,

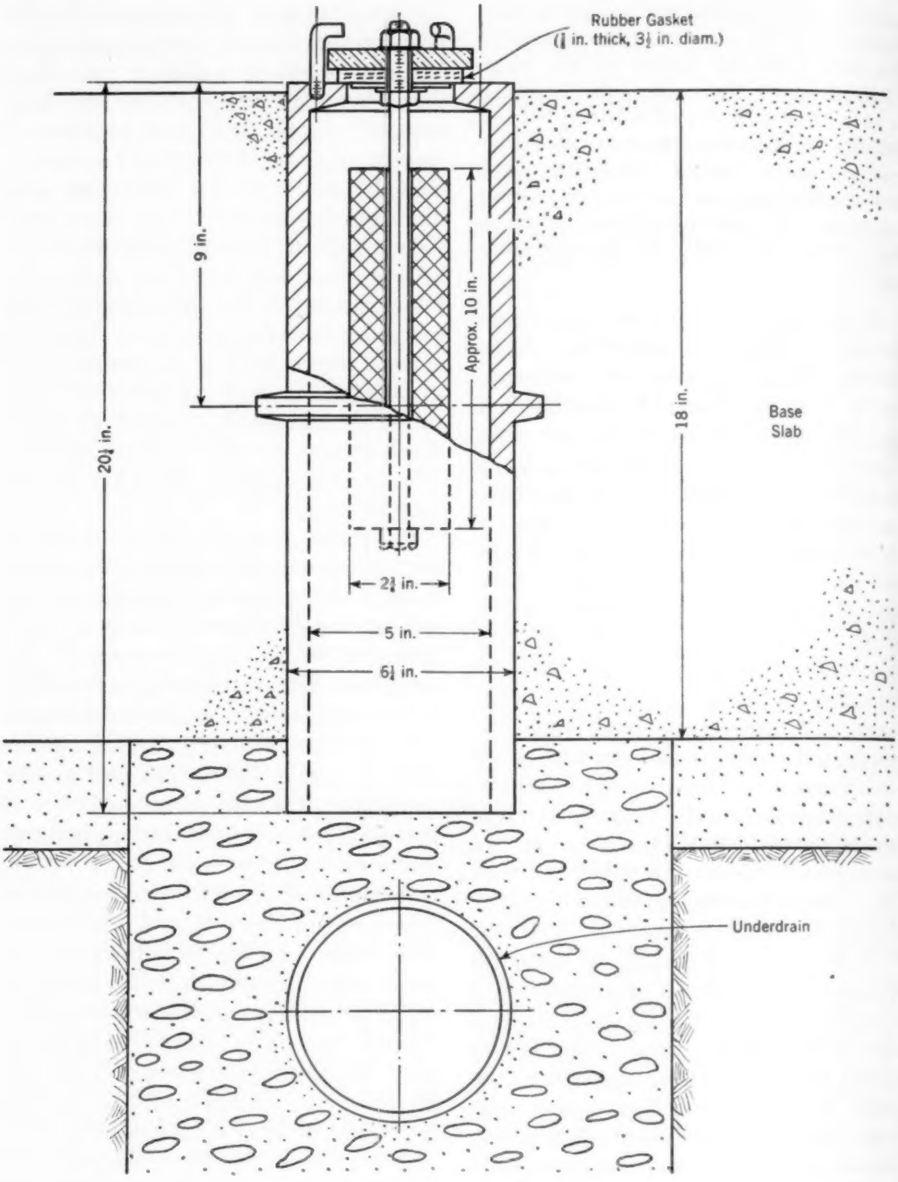

FIG. 3. Pressure-Relief Valve

it is thought, in a diminishing degree, the size of the films increasing until the point is reached where orientation disappears and the water molecules are capable of moving about as free molecules beyond the influence of the fine surfaces. When this condition is realized, the mixture is practically cohesionless and has the characteristics of water.

Cohesion resists displacement in any direction, while friction resists displacement only when motion is attempted parallel to the surfaces of contact.

As the forces of cohesion increase in the mixtures, viscosity increases; and conversely, a decrease in cohesion represents a decrease in viscosity. It follows, then, if the water and fine material phase of the mix is proportioned to develop sufficient cohesion so that the viscosity is great enough to carry the heavier aggregate in suspension (thereby preventing precipitation), the entire mass will behave as a homogeneous entity, and the potential

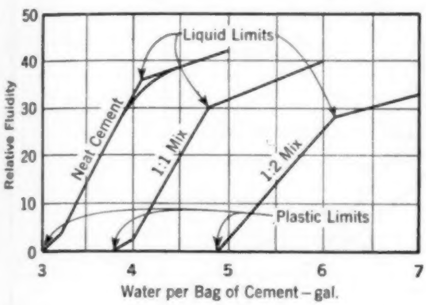

Fig. 4. Fluidity Characteristics of Mortars

compressive strength of the mix will be developed. If the mixture contains sufficient fines in correct combination with water, the internal resisting forces of friction and interlocking will disappear or be minimized and will give way to cohesion.

As a check on the foregoing hypothesis, various mortar mixtures were prepared and passed through a short tube 2 in. in diameter. The time of discharge of a volume was taken as the measure of the total forces resisting flow, in much the same manner as the relative viscosities of fluids, such as oils, are measured through various types of orifice viscosimeters. After the time of discharge of the same volume of water had been determined, the relative viscosities of the various mixtures were computed, and the reciprocals of these viscosities were taken as the relative fluidities. The formula used was:

$$\frac{R_2}{V_1} = \frac{d_2 t_2}{d_1 t_1}$$

where R_2 equals the relative viscosity of the mortar; V_1 equals the viscosity of the water; d_2 is the density of the mortar; d_1 is the density of the water; and t_1 and t_2 equal the time of efflux, in seconds, of the water and mortar,

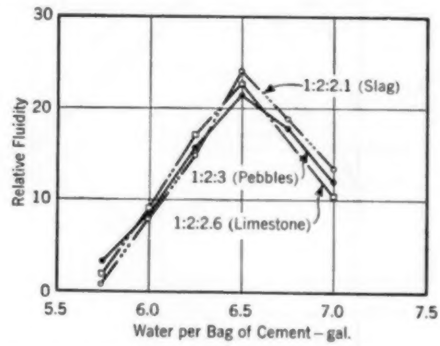

Fig. 5. Fluidity Characteristics of Concrete Mixtures

respectively. Relative fluidity, then, is $\frac{1}{R_2} \times 100$.

The data obtained for three mortars —neat, 1 : 1, and 1 : 2—are shown graphically in Fig. 4. Referring to these curves, it will be noted that each mixture undergoes three stages of wetting. The first stage is believed to define the amount of water necessary to satisfy the individual particle wetting requirements and to put the mass into the plastic state. The point of zero fluidity for each mixture represents the condition of impending flow, and is designated as the Plastic

Limit. The second stage may be termed the cohesive range and reflects the ability of the particles in the mix to hold water in the film phase. It will be noted that in this stage small increments of water produce large increases in fluidity, as represented by the slope of the curves, up to a point which may be designated as the Liquid Limit; between the Plastic and Liquid Limits, represents the true plastic range.

With the limits of the plastic ranges of mortars fixed, the next step was an attempt to determine the quantity of mortar required to insure workable concrete mixtures. An attempt was made to construct a viscosimeter or fluidity meter large enough to measure

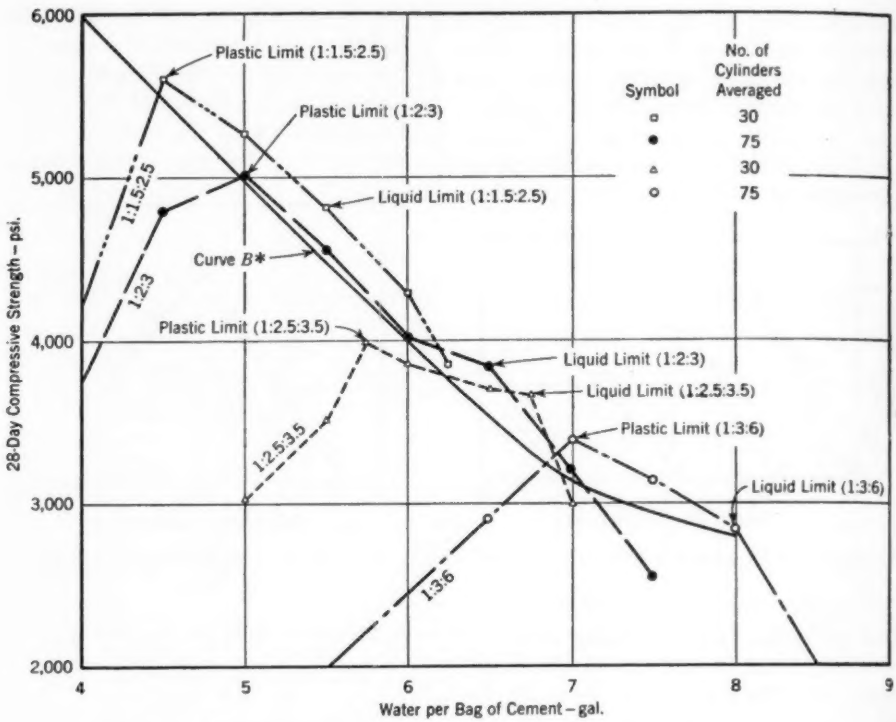

FIG. 6. Water and Strength Relationships of Concrete Mixtures

* Taken from *Design and Control of Concrete Mixtures* (5).

yond this point the fluidity increases at a much lesser rate. Those portions of the curves to the right of the Liquid Limit represent the stage of saturation, with little or no cohesion, and the dropping off of fluidity reflects the predominance of the other two internal forces, particle friction and particle interference. The second stage, be-

the fluidity characteristics of concrete mixes, at the same time holding proper similitude with the smaller one used in the mortar studies. This resulted in a tube 12 in. in diameter, the lower end of which was tapered into an orifice 6 in. in diameter. Concrete mixes were placed in this tube to a level giving a 54-in. head on the

orifice, and a fluidity study was made of them exactly like that conducted and computed for the mortars, substituting, of course, the proper weights and times of efflux in the relative fluidity equation.

From this phase of the investigation it was learned that the fluidity characteristics of the various concrete mixes studied were practically identical, provided that the ratio of the absolute volume of the mortar in the mix to the volume of the voids in the coarse aggregate was 2.50 : 1 or greater. This relationship was found to hold for all coarse aggregates investigated, including pebbles, crushed limestone and slag. Curves of the fluidity characteristics of three concrete mixes composed of 1 : 2 mortars and varying amounts of coarse aggregates are given in Fig. 5. Each point is an average of three runs. In each mix shown, the ratio of mortar to voids was held at 2.50. It may be seen from the graphs that the fluidity characteristics of the mixes are practically identical. It will also be observed that the fluidity of all the mixes increases to a maximum at a water content of 6.5 gal. per bag of cement and then falls off rapidly as more water is added. The 6.5-gal. point checks very closely with the Liquid Limit, 6.25 gal. per bag, found for the 1 : 2 mortar mix (Fig. 4).

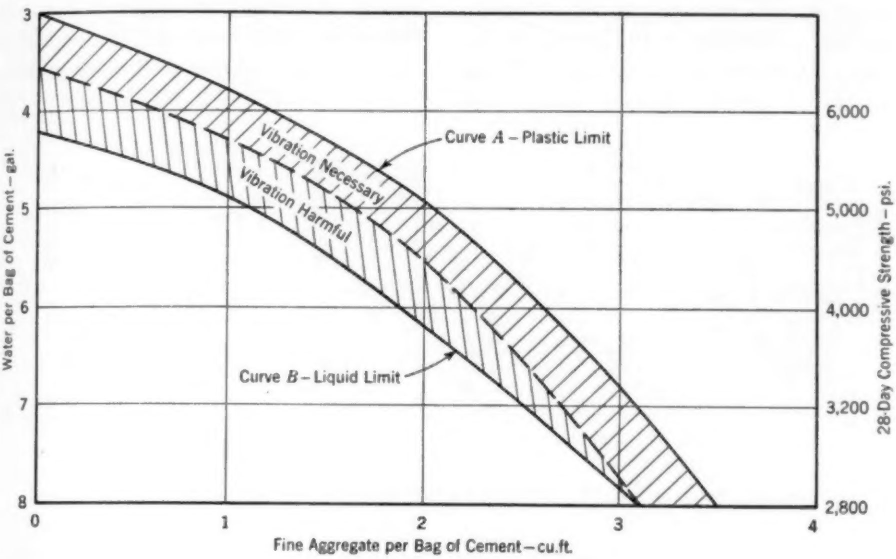

Fig. 7. Fluidity and Strength Data

Standard 6 × 8-in. cylinders were made from all batches of concrete used in the fluidity studies, as well as from mixes too dry to pass through the orifice of the large meter. The cylinders were tested in compression and the 28-day strengths obtained. In Fig. 6 four of the complete strength curves are plotted for mixtures with gravel as the coarse aggregate, and a water-strength curve is superimposed. From these curves it is seen that the strength of the mixes becomes greater with an

increase in water until a maximum is reached at the Plastic Limit. With further increases of water there is a gradual decrease in strength until the Liquid Limit is attained, where the law changes abruptly and there are large decreases in strength with small increments of water.

The mortar fluidity and concrete strength data have been rearranged graphically (Fig. 7) to facilitate their use in designing concrete mixes.* An example will be given to illustrate the method. Assume it is desired to design a concrete mix having a 28-day compressive strength of about 4,500 psi. and possessing maximum workability for placement in intricate formwork in a structure similar to the Northeast Station Reservoir. From the graph in Fig. 7, we find that the required strength will obtain at about the middle of the plastic range of the 1:2 mortar, with a water content of 5.5 gal. per bag of cement. Assume that the cement weighs 94 lb. per cubic foot and has an apparent specific gravity of 3.10; and that the sand weighs, surface dry, 110 lb. per cubic foot and has a specific gravity of 2.65. The coarse aggregate will be assumed to have 36 per cent voids. The absolute or solid volume of the mortar for the assumed conditions would be: cement —$(1 \times 94) \div (3.10 \times 62.5) = 0.49$ cu. ft.; sand—$(2 \times 110) \div (2.65 \times 62.5) = 1.33$ cu.ft.; water—$5.5 \div 7.5 = 0.73$ cu.ft.; the total absolute volume is therefore 2.55 cu.ft. and the ratio of the absolute volume of fine aggregate to the voids in coarse is 2.50:1. Now, if X represents coarse aggregate in cubic feet:

$$\frac{2.55}{0.36\ X} = 2.50$$

$$X = 2.8$$

and the required mix would be 1:2:2.8.

If the above mix were adopted, the mixing water could be varied from approximately 5 to 6.5 gal. per bag of cement to meet job exigencies, and it would still possess the desirable plasticity and workability while yielding concrete of maximum strength and watertightness in the structure.

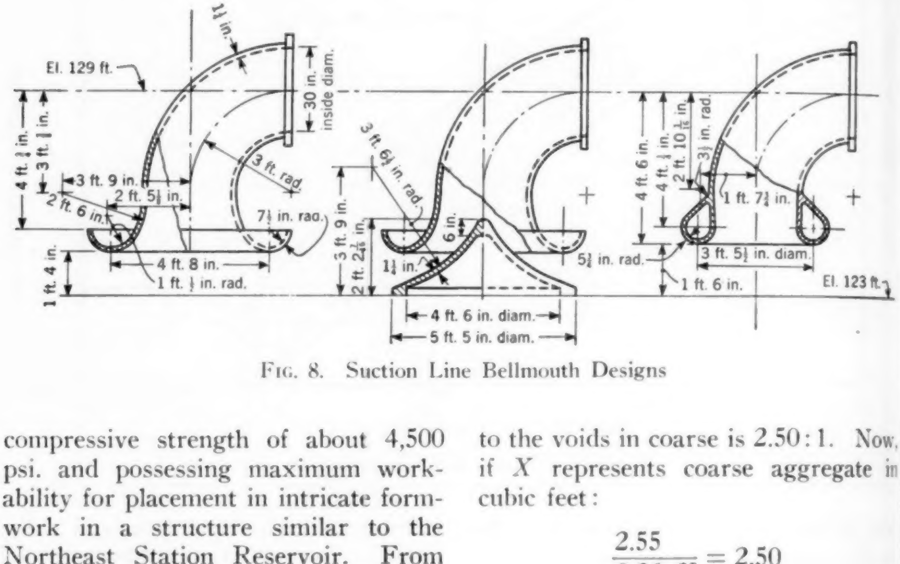

Fig. 8. Suction Line Bellmouth Designs

* The reference in Fig. 7 to vibration applies only to concrete mixes in which the ratio of the absolute volume of the mortar to the voids in the coarse aggregate is greater than 2.50. All mixes with ratios less than 2.50 require vibration.

On the basis of this investigation and after a period of almost seven years of testing the results, these specification requirements were set up for the control of the concrete to be placed in the reservoir: "The water in the mix, including the surface moisture carried by the aggregates, shall not exceed 6.25 U.S. gal. per bag of cement for all components of the structures, excepting the top and bottom slabs of the reservoir. The water in the mix for the concrete to be placed in the top and bottom slabs of the reservoir, including the surface moisture carried by both the fine and coarse aggregates, shall not exceed 5½ U.S. gal. per bag of cement. The proportion of cement to fine aggregate in the mix shall be 1 bag of cement (94 lb.) to 2 cu.ft. of fine aggregate. The minimum ratio of the absolute volume of the mortar to the volume of the voids in the coarse aggregate shall be 2.50."

TABLE 1

Gradation of Fine Aggregate

U.S. Standard Sieve Series	Total Passing, by Weight
	per cent
⅜ in.	100
No. 4	95–100
No. 8	65–95
No. 16	45–80
No. 30	20–55
No. 50	5–30
No. 100	0–10

The aggregates used in the investigation conformed to the gradations in Tables 1 and 2. All proportions are expressed in volumes but were batched by weight. The unit weights of the fine and coarse aggregates were determined, in surface-dry condition, in accordance with the "Standard Method of Tests for Unit Weight of Aggregate," A.S.T.M. Designation C29, using the 1-cu.ft. capacity container having a circular cross section. Portland cement meeting the requirements of A.S.T.M. Designation C9–38 was used throughout the tests.

Pump Suction Line Bellmouths

Two different types of bellmouths (Fig. 8) for the suction lines of the temporary booster station are provided, upon which loss of head experiments will be attempted after the station is placed in operation. One type has a well-rounded intake and is designed to provide a constant rate of change in velocity from the entrance to the junction of the bellmouth section with the constant-diameter suction line. This type will be set with and without hydrocones and the losses compared.

TABLE 2

Gradation of Coarse Aggregate

Sieve Size *	Total Passing, by Weight
	per cent
2 in.	100
1½ in.	95–100
1 in.	60–90
½ in.	25–55
No. 4	0–8

* Square openings.

The other variety is designed on the theory that if the area of the bellmouth is made equal to an orifice which will discharge a stream no wider than the diameter of the suction line, there will be no contraction of the stream, and consequently the abrupt expansion losses will be eliminated (6). This means that the area of the bellmouth would be equal to the area of the suction pipe divided by the contraction factor. The diameter of the required

bellmouth, then, would be equal to 1.28 times the diameter of the pipe, for a contraction factor of 0.61.

In this design, the outside diameter of the pipe was used, which, when multiplied by 1.28, fixed the diameter of the entrance of the bellmouth at $41\frac{1}{2}$ in. and the radius of rounding at $5\frac{3}{4}$ in.

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Public Water Supplies in Mississippi

By H. A. Kroeze

A paper presented on May 23, 1947, at the Alabama-Mississippi Section Meeting, Birmingham, Ala., by H. A. Kroeze, Director, Div. of San. Eng., Mississippi State Board of Health, Jackson, Miss.

THE state of Mississippi lies within the Gulf Coastal Plains, but, contrary to the belief of some people who are not familiar with its surface conditions, it is by no means a low, swampy country. The topography is made up of a diversity of minor surface features and the state is divisible into at least ten distinct physiographic districts. In all but two of these, the main features of the relative altitudes and land forms have been produced by the differing effects of erosion on the materials that immediately underlie the surface. Since formations composed predominantly of sand and sandstone resist erosion more effectively than do those of chalk and clay, there has resulted a number of hilly uplands which serve the state as catchment areas for underground waters. The two districts whose main features have not been primarily determined by erosion are the Yazoo Delta, a large alluvial area in the northwestern part of the state bordering the Mississippi River, and the Coastal Pine Meadows, a narrow, low-lying district which borders the Gulf of Mexico.

Sources of Supply

Mississippi has a mean annual precipitation varying from approximately 50 in. in the north to slightly over 60 in. in the southeast near the Gulf of Mexico. The greater part of the ground water of Mississippi is derived from rain which falls within the borders of the state. The Tuscaloosa formation, however, which appears in the extreme northeastern part of the state, obtains most of its supply in the hills of northwestern Alabama.

The strata underlying the surface of the state are saturated with water below the level known as the water table, which ranges from the surface to a depth of 100 ft. or more in different sections. Although the beds are saturated to the water table, they do not all yield their water with equal readiness. But the more porous sand and gravel strata are sufficiently distributed to enable most municipalities to secure their water supply from underground sources, generally in large quantities. Consequently, a large majority of the public water supplies of the state is derived from deep wells.

At present there are 207 public and semi-public water supplies in Mississippi. Of this number 193 are derived from deep wells, 10 come from springs and only 4 are obtained from surface sources. Because of the abundance and distribution of underground water in the state, all industrial water supplies are also obtained from that source. Though the underground supply is still plentiful, the increasingly heavy draft has demonstrated that in some parts of the state the quantity of water avail-

able from the beds now being drawn upon is limited, and that at the present rate of removal the supply may eventually become seriously depleted.

A good example of depletion is afforded in a number of areas by wells which originally flowed freely, but in some of which the static water level has now dropped as much as 70 ft. below the surface. Because of the excessive draft from the strata underlying the Mississippi Gulf Coast area during the war, many wells in this region stopped flowing. As a result, several municipalities were forced to install deep well pumps in existing wells and to drill new ones. Geologists have expressed fear of the possibility of salt water encroachment in these water-bearing sands. In an effort to conserve water, all the municipalities affected have completely metered their systems since the war began. The closing of most of the military establishments has also helped to improve the situation.

The general distribution of underground water resources in Mississippi has led most municipalities to secure their public supplies from wells for reasons of convenience and economy. Of the four municipal supplies from surface sources, three are obtained from rivers and one from impounded reservoirs. These cities have resorted to surface supplies either because of the scarcity of underground resources in their immediate vicinity or because of the unsuitable chemical characteristics of the underlying waters. The four municipalities—among the largest in the state—maintain conventional water purification plants employing coagulation, filtration and chlorination in the processing of the water.

The ten municipalities depending on springs for their public water supply likewise make use of such sources chiefly because of the scarcity or chemical characteristics of the underground waters in the vicinity. These supplies generally are serving small towns, and their development is less costly than that of deep well supplies or the treatment of a water unsuitable for domestic purposes. The chemical quality of these spring waters is excellent for domestic use.

Water Quality and Treatment

Although deep wells are almost universally used as sources of the municipal water supplies in Mississippi, the chemical quality of the waters varies considerably. On the whole, the total solids content is satisfactory, and the waters are generally very soft, though the hardness ranges from zero to as high as 425 ppm. Of 213 chemical analyses of water from 159 supplies, only eight samples showed a hardness content from 65 to 100 ppm.; and in only twenty was the hardness above 100 ppm. There are two municipal water softening plants in the state, but several other cities could economically soften their water. Some municipalities with supplies of relatively high hardness have wells in other strata which produce soft water, though of lesser yields. The mixing of the waters from the different strata results in a water of sufficient softness to obviate the necessity of installing softening equipment.

The chief chemical constituents of many of the underground waters in Mississippi which cause difficulty from the standpoint of domestic use are iron and free carbon dioxide. Numerous municipal supplies are high in carbon dioxide content and low in pH. Others are high in both carbon dioxide and iron. Such waters are found frequently

in most districts of the state other than the Yazoo Delta and the coastal plain area bordering the Gulf of Mexico. Treatment to eliminate the undesirable chemical constituents is becoming increasingly popular with the public. At present there are 33 water treatment plants in the state for the removal of carbon dioxide and the adjustment of the pH, and for the removal of iron, or both. As part of the postwar program, plans have been prepared for eight additional treatment plants of this type.

In one municipality having a water excessively high in iron and free carbon dioxide, a ferro-filter has been installed to determine the effectiveness of this method. The city now has a conventional plant which processes the water by aeration, sedimentation, filtration through rapid sand filters, lime treatment and chlorination. If this type of filter will handle the water satisfactorily, directly from the ferro-filter to the clear well, it is believed such installations will prove more economical in first cost and in operation than the method now generally used in the state.

Fluorine in appreciable quantities does not appear in Mississippi underground waters except in one small area in the east central portion of the state bordering on the Alabama line. In this vicinity there are several municipal supplies in which the fluorine content is in excess of the presently reported safe threshold for avoiding damage to the enameled surface of the teeth. One municipality has installed a fluorine removal plant, the only such plant in the state.

Though a vast majority of the public water supplies in Mississippi are derived from underground sources, the feeling among municipal officials is increasing that all water supplies should be treated with chlorine as an added factor of safety. At present 63 municipalities chlorinate their water either on the suction or discharge side of the pumps, and three of these cities also apply ammonia in combination with chlorine.

Because Mississippi has no natural electric power resources, complete electrification of the public water supplies was somewhat slow. The general spread of power transmission lines throughout the state during the past two decades has led to more reliable and economical power sources for water works purposes. Today all public water supplies in the state, with one exception, are completely electrified, although several of the larger cities still maintain stand-by steam equipment for emergencies, and to improve their fire insurance rating.

Administration

The supervision and management of water works still leaves much to be desired in many places. On account of the large number of small communities in the state, the operation of the water works is often a responsibility of the town marshall. Since he is an elective official, frequent changes occur and the person elected to this office generally possesses no qualifications as a water works operator. Even in municipalities where the superintendent of the water plant is an appointee of the administration, changes are often made. In the larger cities, tenure of office is more permanent and the type of person employed is usually more suitable for the position. Furthermore, since employment is more secure, executives have an incentive to improve their knowledge of the water works

field. Those cities in which the operation of the water works and the other municipal utilities—such as electricity, gas and sewerage—are set up under a nonpolitical utility commission generally have the most efficiently managed water works systems in Mississippi. The few cities where a well-trained graduate engineer is in direct charge of the water works under the nominal supervision of a city commissioner constitute an exception.

The state has yet to institute short courses for water plant operators, although the need undoubtedly exists. Efforts are being made to persuade one of the state colleges to offer the facilities of its engineering school for a program of this type in cooperation with the State Board of Health. Such a program, besides giving water plant operators good training in their important job, would have a stabilizing influence on tenure of employment and would stimulate municipal officials to give some consideration to qualifications when appointing their water works superintendent.

Planned Improvements

In the field of postwar water works development, 40 municipalities have completed plans for new water systems or extensive improvements to existing facilities. The program is expected to cost approximately $7,000,000, including an estimated $600,000 for new systems for small municipalities. Thirty-one of these municipalities have secured advances totalling over $300,000 from the Federal Works Agency to pay for the engineering design. Present construction costs, however, have retarded the letting of contracts for the greater portion of this work, though over $1,500,000 worth of bonds has recently been voted by a number of cities which intend to proceed with their improvements if favorable bids can be secured.

Basic Water Problems in Florida

By A. G. Matthews

A paper presented on Nov. 21, 1947, at the Cuban and Florida Section Meeting, St. Petersburg, Fla., by A. G. Matthews, Chief Engineer, Division of Water Surveys and Research, State of Florida, Tallahassee, Fla.

PROBLEMS are presented in the water supply of Florida by floods and other factors. Primary emphasis will be placed on the peninsula in this article, which, because of the lack of essential data, cannot be detailed. For the same reason, no discussion of possible solutions seems appropriate.

Basic Problem

Briefly, the basic problem results from the vagaries of the weather, and the harmful interference of man with the fresh water resources of the state. In more detail, it can be stated that, except for the northern tier of counties, the fresh water supply of Florida is derived almost entirely from local rainfall. This island condition is complicated by the fact that the rainfall is most unevenly distributed over the months and years. As a result, the flat, ill-drained lands suffer from alternating drought and flood. Moreover, in many localities the underground water supply has become unsatisfactory.

As a consequence, the state legislature in 1947 authorized a study to devise and recommend a statewide plan to control floods, to eliminate the effects of drought and the depletion of all surface and subsurface water supplies, and to preserve the water resources of the state for the use and benefit of all of its people.

For the purposes of this paper, the various elements comprising the basic problem can be broken down into two categories: (1) those due to natural causes; (2) those due to man and his works. Although present studies have not progressed far enough to yield quantitative results, it is believed that the information included in this article is essentially correct.

Natural Causes

The natural elements which constitute the basic problem also impose the framework within which it must be solved. Although many complexities are involved, there are four elements —climate, geography, topography and geology—which are fundamental.

1. *Climate.* The climate is subtropical, with no snow and rare freezes. The annual rainfall varies from 30 to 85 in. a year, falling mostly between May and November. Monthly rainfall in. Several successive years of rainfall below or above normal have occurred. Evaporation rates are exmay vary from nothing to possibly 35 tremely high and may even exceed the annual rainfall. Hurricanes may occur in the summer and autumn and are frequently accompanied by heavy rains.

2. *Geography.* The state consists of a narrow strip along the gulf coast and a peninsula thrusting south 460 miles, between the Gulf of Mexico on

the west and the Atlantic Ocean on the east. The warm waters of the Gulf Stream flow north between the east coast of the peninsula and the Bahama Islands. This peninsula, 149 miles across at its widest part, thus lies between two warm bodies of water and in the path of the summer trade winds blowing across the Gulf Stream.

3. *Topography*. The topography of Florida is characterized by low relief throughout. Except for the narrow strip along the mainland coast, the slopes are flat, the drainage systems and divides are ill defined, and there are innumerable lakes, swamps and depressions. Only a few streams enter the peninsula from the continent.

A central ridge, generally about 90 ft. above sea level, runs south down the state from the Georgia line to the vicinity of Fisheating Creek. The hills of peninsular Florida are usually so low as to convey the impression of a flatland lying nearly at sea level. The streams flowing down such slopes are sluggish, their valleys broad and their divides problematic. Dam and reservoir sites for the storage of large quantities of water, or for the generation of large amounts of hydroelectric power, are not economical to develop. Because of the flat terrain, the runoff from rains is slow, and excessive rains result in the sheet-flooding of large areas. Consequently, flood stages are of long duration, but damage from impact and erosion by swiftly flowing flood waters is rare.

4. *Geology*. The principal limestone stratum underlying peninsular Florida lies generally in an elongated dome, with its major axis roughly north and south. Various additional layers of lime rock and lime conglomerates were deposited around the sides of this dome at successively lower levels of the sea. While this is, of course, a grossly unscientific and over simplified statement, it does convey the basic picture of successive layers concentrically exposed, not unlike a sliced onion.

The rains falling on these exposed layers percolate through them to furnish important quantities of water, and it is believed probable that most of the underground water of Florida originates in this way. The varying permeabilities of the different strata account for the fact that some surface areas are supplied by flowing wells and others by pumping, while still others are unable to find an underground water supply. These underground waters are utilized by 92 per cent of the municipal water supply systems of the state and are also the source of the many large surface and underwater springs. The discharges from the surface springs which have been measured indicate that these springs utilize all the rain falling on 1,600 square miles. The amount of water discharged by the subaqueous springs has not been determined, nor is the total useful amount of water contained in the rocks known. It must be pointed out, however, that not only do these springs use important quantities of water, but, as they continue to flow, their waters keep on dissolving larger and larger channels and paths of percolation through the lime rock. It is thought possible, therefore, that the flows from these springs will increase with the passage of time. The rate of this increase is a matter of speculation, of course, but the probability should be taken into consideration in planning future water supply systems.

Artificial Causes

As is unfortunately usual, man has made worse the situation imposed by

nature. He has also suffered damage to his works from both natural and artificial causes. Although it is not strictly logical to lump together both the evils wrought by man and the damage to his works, the two items are so closely related that grouping them to save repetition seems justified.

1. *Droughts and floods.* Alternating droughts and floods have caused major damage to crops, cattle, transportation, municipalities and man-made structures, particularly in south Florida. The total amount of damage inflicted over the years is yet to be determined, but partial figures presently available show the loss to be tremendous.

2. *Wastage.* The wastage of water from flowing wells and springs, and from air-conditioning and other industrial uses, has not only depleted the ground water but has also allowed the intrusion of salt water into the aquifers. Most communities have had to meet the salting of wells and the lowering of water levels by making additional and expensive installations.

3. *Pollution.* The pollution of both surface and subsurface waters by domestic and storm sewerage, and by industrial waste, has been widespread despite restrictive statutes. Occasionally the guilty community has even fouled its own water supply. All such contamination has become so dangerous to public health as to necessitate expensive water treatment plants.

4. *Salt water encroachment.* Salt water seeps into the aquifers because of wastage or overuse and by means of wells improperly cased or plugged, or by way of ruptured and rusted-through well casings. At and near the surface, salt water has intruded along the drainage canals where water-control gates or salt-water barriers are lacking. In the absence of a head of fresh water in the canal and in the ground, salt water has infiltrated into the soil from the canals and from the seashore. After infiltration, this water is drawn to the surface of the ground by capillary action and there evaporates, leaving a soil contaminated with increasing quantities of salt.

5. *Overdraining.* The overdraining of muck and peat soil has resulted from improperly controlled drainage work. This has been followed not only by important decreases in the elevation of the surface of the ground, but also by irreparable loss due to the total destruction of the soil by fire.

6. *Leaching.* The leaching from the soil of minerals vital to plant and animal growth has followed the alternate flooding and drying of the soil.

7. *Promotional projects.* Projects conceived and executed primarily for profit, and involving the reclamation of lands by drainage, have frequently resulted in poorly engineered, extravagantly financed and unwise construction. Some of these works have permanently injured the land and have occasioned great financial losses to the communities involved.

8. *Lack of coordination.* Uncoordinated local attempts to deal with water problems have frequently worked harm to other areas. Typical instances are the draining of uplands by means which increase flood damage in the lowlands; protecting lowlands from floods by means which increase flood damage in the uplands; and diverting waters from one basin to another for purposes of local improvement without considering the damages resulting from the diversion in other areas.

Conclusions

So large an amount of necessary data is not yet available that no attempt can be made at the present time to de-

rive a solution for these problems. But it is possible to discuss the courses of inquiry and investigation which should be followed to furnish this required information.

A brief review of the data needed indicates that complete information on surface and subsurface conditions is required for the entire state. Topographic and soil suitability maps are necessary, together with stream-flow, rainfall, evaporation and transpiration records. Complete subsurface information on the reservoir capacity, the rates and directions of the flow in the aquifers, and the location and extent of the areas and rates of recharge are also essential. Population and economic development studies, with present and future water requirements, must be furnished, as well as estimates of the annual damage from flood and drought.

It is obvious that all of the foregoing cannot be accomplished over the entire state in a short period of time. Years of records cannot be improvised from a single year's observation. The gathering of certain classes of information is therefore a lengthy, continuing process which should be set up in such a way as to blanket the entire state. Within the limitation imposed by available funds, this program has long been in effect, but its amplification by the installation of additional observation stations is necessary.

Other classes of information—such as topographic, soils and damage surveys—require many field workers and cannot be carried on simultaneously over the entire state without an excessive financial outlay. These investigations must be scheduled for each basin, or part of each basin, in succession and in order of the priority of need. Similarly, the detailed study of the solution for each basin and each area must proceed in succession rather than simultaneously for the entire state. This process is now going on, largely because of the aroused interest of the people in south Florida, implemented by appropriate congressional action and the work of several federal agencies.

In the author's opinion, there is no engineering problem presented here that cannot be solved completely, or at least practically, for the major benefit of the people. Such a solution, however, depends entirely upon the combined expression of the wishes of the voters themselves. Without concerted action, the most perfect engineering plan becomes merely a useless academic exercise. With it, the future development of Florida to heights beyond the fondest imaginings can be assured.

Conservation and Control of Texas Water Resources

By E. V. Spence

A paper presented on Oct. 13, 1947, at the Southwest Section Meeting, Amarillo, Tex., by E. V. Spence, Chairman, State Board of Water Engineers, Austin, Tex.

IMPOUNDING the flood flows of Texas rivers in reservoirs and making that water available for beneficial use, as well as developing and utilizing ground water so that each underground reservoir will supply water of good quality at an economical rate for an indefinite period of time, should have top priority in Texas. These are problems that extend far beyond a single community's boundary, a fact which the Texas legislature recognized when it created the Texas State Board of Water Engineers.

Legislative Enactments

In 1913, under legislative enactment, the State Board of Water Engineers was organized and charged with the administration of laws relating to surface waters in Texas. Later legislation extended the duties of the board to include the investigation of ground water resources and gave it some authority over the wastage of water from artesian wells.

Individuals, corporations, districts or municipalities desiring to appropriate water from the streams of Texas for any beneficial use permitted by law are required to make application to the board for a permit for such use. Public hearings are held on these applications and investigations are made into the adequacy of the available water supply, the merits of the plans for such work, and the possibility of interference with existing vested rights. On the basis of these investigations and hearings, the application is approved or rejected.

The laws of Texas provide for the formation of water improvement districts (primarily for irrigation) and water control and improvement districts. The latter have wide powers, including irrigation, drainage, water supply, sewer systems and power development. The Board of Water Engineers is required to pass on plans and bond issues for work contemplated by these districts. This involves the examination and checking of plans and estimates, as well as investigations into the adequacy of both the water supplies and the proposed improvements.

The Board of Water Engineers is made up of three members appointed by the governor and confirmed by the senate for six-year staggered terms. The board's working staff is composed of three hydraulic engineers, one soil testing engineer, one chief clerk and two secretaries.

General Description

Factual data revealing the wide variations in the quantity and quality of

both surface and ground water are being collected by this board in cooperation with the U.S. Geological Survey and other agencies. Such data now form the basis for the intelligent development and equitable distribution of water supplies.

Water, like soil, is a basic natural resource upon which the community, the state and the nation must depend in part for their economic stabilization. The development of a community stops when its water supply ceases to meet the over-all demand. Many Texas towns have now outgrown their present sources of water supply. Through river authorities or water districts created by the legislature, many communities are endeavoring to develop new sources of water of proper quality for municipal, industrial and irrigation purposes. Other communities need flood control reservoirs. Water pollution in some areas is becoming a menace to health and is rendering the water worthless for subsequent users. A river basin, as well as a ground water reservoir, may extend through several communities. The solution of these water problems, therefore, is a matter of state interest.

Heavy rainfalls wash the soil down to the sea and destroy property. In contrast, all sections of the state experience prolonged droughts that continue, at times, from one to three years. The 1945–46 drought in west Texas is fresh in the memory of the people of that section, and the entire state is now suffering from a drought condition which is endangering its economic stability. During drought periods the farmer, the domestic water plant operator and the industrialist resort to every possible means to conserve water for beneficial use, and during major floods they fight to preserve their property.

The farmer living on the top of a hill has learned, like the man living on a river flood plain, that uncontrolled flood waters can exert a destructive force. Flowing water, like atomic energy, must be channeled to the proper uses of man. Through more intelligent, basin-wide planning and building, flood flows can be controlled and utilized to a considerable extent from the time the raindrop falls on the land until it moves out of the river mouth to the sea. Ground water supplies can be maintained and fully utilized indefinitely if they are not overpumped or polluted. The quality of both surface and ground water supplies is also a controlling factor in water-use projects.

Within the past six years industrial plants costing more than $1,500,000,000 have been erected in Texas. Data revealing the quantity and quality of water available for many of these developments had no small part in their location, and Texas has lost new developments because similar information could not be obtained for some areas. The irrigated acreage from surface and underground sources in Texas increased to 2,400,000 in 1947. The earned income of the state has been increased by these progressive developments. Many of the industries are utilizing chemical processes to produce goods from agricultural and forest crops and from oil, sulfur, salt and fresh water. Water demands are rising at a rapid rate and the unregulated flow of Texas rivers is failing to meet them during drought periods. In some areas limited ground water supplies also are unable to meet increasing demands, and the withdrawals of

ground water are beginning to lower the water table at an excessive rate.

The State Board of Water Engineers has rendered an invaluable service to the people of Texas through its water resources investigation program in cooperation with the U.S. Geological Survey. Information collected by the board on the quantity and quality of surface and ground water resources is extensively used by state, federal, municipal and private agencies in designing and operating economical water-use and water-control projects, as well as in the design of waterway openings for bridges and other water-use structures.

Surface Water Resources

The average annual runoff of Texas streams is 43,000,000 acre-ft. (14,000 bil.gal.)—a quantity sufficient to supply every man, woman and child in the state with 6,100 gal. daily, or about 60 times the ordinary domestic requirement. To the layman, these facts might be encouraging and the water supply problem might appear to be a simple one, but unfortunately water is not a uniformly distributed natural resource. The unregulated yield of practically all Texas streams varies greatly from day to day and from year to year, although the yearly average yield may be a substantial quantity. Eighty per cent of the average annual runoff, or 35,000,000 acre-ft., occurs in the form of flood flow and is therefore discharged into the Gulf of Mexico within a few days after the flood-producing rains, except where reservoirs are employed to intercept it.

The average annual runoff unit yield is extremely small in west Texas, but it progressively increases, with the rainfall, to the Texas–Louisiana border. It is of interest to compare the surface water yields of west and east Texas. For example, the average annual runoff of the headwater streams of the Red, Brazos, and Colorado Rivers (to the west of the hundredth meridian), the watersheds of which have a combined area of 47,400 square miles, is about 1,000,000 acre-ft. The average annual runoff of 46,000 square miles drained by six east Texas streams—the Sulphur, Sabine, Neches, San Jacinto and Trinity Rivers, and Cypress Creek in northeast Texas—is 21,500,000 acre-ft., or 21½ times greater than an approximately equal area in west Texas. Of the above-mentioned west Texas area, 26,000 square miles contribute no surface runoff to the streams of the region. The rainfall in that noncontributing area is lost by evaporation and transpiration and some replenishes the underground water. Ironically, east Texas at times experiences severe droughts that extend through one or more years; under such conditions, the flow of east Texas streams drops to zero or very small quantities.

Records show that streams in 72 counties east of the hundredth meridian (the eastern border of the Panhandle) and in 69 counties west of that meridian occasionally go dry or the flow drops to quantities that are insufficient to meet municipal, industrial and irrigation requirements.

The impounding of flood flows in reservoirs for beneficial use is comparatively new in Texas. Dallas was probably the first municipality to construct a reservoir of considerable size to impound flood waters for municipal use. Since the construction of Bachman Lake near Dallas in 1902–03, that city has built the California and Car-

rollton dams on the Elm Fork of Trinity River, White Rock Lake and Lake Dallas. The population has now grown beyond the ability of these works to meet the water needs during extended droughts, and the city is at present studying the possibility of constructing a much larger reservoir.

Thirty-four reservoirs, having capacities from 10,000 to 5,720,000 (Denison Reservoir) acre-ft., have been constructed in Texas within recent years, at a cost of more than $150,000,000. Construction by the Corps of Engineers now under way includes Benbrook, Grapevine and Lavon Reservoirs in the Trinity watershed; Dam *B* on the Neches River; Addicks Reservoir on Buffalo Bayou near Houston; Whitney Dam on the Brazos River at Waco; Hords Creek Reservoir near Coleman; and North Concho River Reservoir at San Angelo. Houston, Corpus Christi, Tyler and Colorado City are all planning to construct reservoirs for future water supply purposes.

Some comment on the Canadian River, which traverses the Panhandle, is appropriate at this point. Although continuous records of flow for this stream near Amarillo extend through only a nine-year period, they show that the average annual runoff has been 522,000 acre-ft. The water resources of this stream will eventually be utilized to their fullest extent in the Texas Panhandle, but the engineering, economic and legal problems will have to be solved first.

The Canadian River is an interstate stream, originating in New Mexico and traversing portions of Texas and Oklahoma. Conchos Dam and the associated irrigation project near Tucumcari, N.M., is the largest development to date on the Canadian River. There have been no interstate controversies over the waters of this stream, and, to avoid such controversies in the future, the people of the three states concerned with its future development should begin now the formulation of an interstate water compact for the Canadian River. If approved by all three states, such an agreement would eliminate the prolonged and unpleasant legal conflicts which are certain to arise as the development progresses.

Ground Water

The Texas Board of Water Engineers has been investigating the ground water resources of Texas in cooperation with the U.S. Geological Survey since the fall of 1929. Most of the results of these studies have been published in printed or mimeographed reports, of which about 200 have been released. A considerable number have not yet been published but are available for public reference in manuscript form at the board's office in Austin.

Effect of Increased Use

The outstanding facts disclosed by these cooperative investigations are: (1) The largest supplies of ground water in Texas are in the High Plains region, the Balcones Fault zone and the Coastal Plain area, the last including most of south and east Texas. Smaller supplies occur in parts of north and west Texas. Large areas in the state, however, are practically barren of ground water of good quality. (2) Considering the state as a whole, the ground water resources are very large and, if they are intelligently used, should in the long run prove to be Texas' most valuable underground resource. (3) The use of ground water for public supply, industrial purposes and irrigation has increased enor-

mously in recent years. (4) This has resulted in a continual decline in the water table.

Recent investigations have shown that 681 of the 837 public water supplies of the state are drawn entirely from ground water, and that the total withdrawal for this purpose averages about 270 mgd., the equivalent of 300,000 acre-ft. a year. Present consumption is far greater than it was ten years ago. A total of about 280 mgd. of ground water is used for industrial purposes, which is about twice the amount consumed ten years ago. In the Houston district, for example, the combined average daily pumpage for public supply and industrial use increased from about 49 mil.gal. in 1936 to 120 mil.gal. in 1946. In the San Antonio area, the wells provided about 60 mgd. for public and industrial supply in 1946, compared with about 33 mgd. in 1934.

In the entire state approximately 800,000 acres are now being irrigated from ground water sources as against about 120,000 acres in 1930. Of this total, approximately 650,000 acres are in the High Plains region, 45,000 in the Winter Garden district southwest of San Antonio, 55,000 in the rice-growing areas of southeastern Texas and 25,000 in the Pecos-Balmorhea-Fort Stockton region.

This huge increase in development has been accompanied nearly everywhere by a more or less persistent decline in the water table or artesian head, indicating that the underground reservoirs are suffering a certain amount of depletion. The decline has been most serious and has amounted to partial failure in localities where the supplies are small or of moderate proportions and the ground water reservoirs are least able to stand an overdraft. The decline has been somewhat serious in a few areas of large supply and heavy pumping, but has reached emergency proportions in only one or two such regions. In some areas the decline of the pumping levels and the reduction in yield during seasons of heavy pumping—due to mutual interference among too closely spaced wells—is more critical than the net annual loss from underground storage.

Conservation

A great deal can be accomplished in the conservation of ground water resources by common-sense methods based on a knowledge of the geology and occurrence of ground water, including accurate information regarding the ability of the water-bearing beds to absorb, store and transmit water to wells, and the effect on the underground reservoirs of a known amount of pumping. This knowledge should give warning well in advance of any serious emergency and enable the ground water users to adjust or reduce the draft in time, if, of course, they are so inclined. Often the apparent shortage is due to too close spacing of the wells. Adequate additional supplies frequently can be obtained by spreading the pumpage over wider areas. Sometimes larger supplies of water of better quality can be obtained for public or industrial use by installing new wells in districts farther up the dip and nearer the ground water intake areas than present wells.

Importance of Cooperation

Cooperation among the various ground water users can accomplish a great deal, as a few illustrations will demonstrate:

In response to reports and recommendations by the Board of Water

Engineers and the U.S. Geological Survey, Houston has redistributed its pumpage for public supply by installing a new well field southwest of the city at comparatively remote distances from the center of industrial pumping in downtown Houston and the Pasadena area east of the city. In addition, plans have been completed by the city and construction started on a project to relieve the draft on the underground reservoir by bringing in water from the San Jacinto River. By means of this development the city itself, and several of the large industries in the ship channel area now drawing heavily from their own wells, will use river water to supply a part of their needs. It is interesting to note that, as a result of the shift of a part of the city pumpage to the southwestern field, the graph of water table decline in downtown and eastern Houston—which has been uncomfortably steep—has started to level off, indicating a gratifying approach toward equilibrium. It is nevertheless hoped that the construction of the San Jacinto project, which has been delayed because of high prices and scarcity of materials, may be resumed before long.

In the Texas City-Galveston area the artesian head has declined over 100 ft. since 1933, following an increase of more than 300 per cent in the pumpage for public and industrial supply. This decline has been attended by increased salinity of the ground water in parts of the area, a situation which has been met at Galveston by shifting most of the pumpage to wells a few miles to the north of the old Alta Loma well field in the up-dip direction of the water-bearing beds. Since this shift, water of excellent quality has been obtained. Best of all, cooperative plans are well under way looking toward the ultimate solution of the entire regional problem by bringing in surface water from the San Jacinto or Brazos Rivers to supplement the failing supply of ground water.

Fort Worth and Dallas formerly drew heavily on ground water for public supply, but both cities long ago decided that the ground water reservoirs were inadequate to meet their heavy demands. Accordingly, they turned to surface water, leaving the ground water reservoirs to be exploited by suburban consumers and by industries through privately owned wells, to the apparent advantage of all concerned.

A few years ago, following an extensive investigation by the Texas Board of Water Engineers and the U.S. Geological Survey, El Paso decided to supplement its ground water supplies with water diverted from the Rio Grande. This dual plan is now in operation; the draft on the underground reservoir is being kept within safe limits, and at the same time the demands for surface water are not excessive. Thus the needs of the city are served without unduly depleting the ground water supplies or seriously injuring the interests of the irrigators who depend upon Rio Grande water.

Amarillo also has need of a larger water supply. This can be obtained from wells in areas not too far from the city, which up to now have not been developed for irrigation and are not likely to be because the lift is somewhat above the practicable irrigation limits. At some increase in cost, due to the higher lift, the city can obtain the necessary additional water without serious interference with the irriga-

tion farmers in an important part of its trade territory.

Lubbock, in cooperation with the board, has made extensive and rather costly investigations in areas surrounding the city to try to augment its water supply without too seriously affecting the irrigation requirements of the area.

The cooperative spirit is finding expression in other parts of Texas. For example, plans are gradually being worked out for relieving ground water shortages at Colorado City, Big Spring, Midland and Odessa in western Texas by bringing in surface water from the Colorado River under a joint share-the-cost program.

A similar cooperative project, involving flood control and the development of surface water to supplement ground water for industrial supply, is being planned in the Longview-Kilgore-Gladewater district of northeastern Texas.

The use of excessive quantities of fresh ground water for cooling in connection with industrial operations is being discouraged in certain localities. Some of the industrial operators of the Gulf Coast are pumping salt water for cooling purposes from nearby bayous or from wells that draw from sands below the fresh water horizons. Cooling towers are being better maintained than formerly. The use of ground water for cooling purposes, however, is still greater than it should be.

Public Support for Legislation

It is an old saying that a law must have popular support to be enforcible. For water laws, community support is invaluable. For example, the waste of water from an artesian well is prohibited by law in Texas (Revised Civil Statutes of Texas, Vol. 2, 1925, pp. 2198–2200, Articles 7600–05, 7613–15). The State Board of Water Engineers has been unable to enforce this law fully because it does not have sufficient popular support in the districts where the waste occurs. The people often are indifferent, and sometimes actually hostile, to such control. Flagrant cases involving damage from the waste water to property other than that of the owner of the well are readily handled, but enforcement when the waste water is discharged into streams, or affects only the lands of the owner, is difficult. Progress, however, is being made through investigation and publication of the facts regarding the magnitude of the waste and its effects on the underground reservoirs.

In Kleberg County, for instance, an investigation several years ago disclosed that the artesian pressures were falling and that a part of the decline was due to the waste of water from uncontrolled flowing wells. Publication of the results of the investigation brought the facts to the attention of the officials of the King Ranch and other landowners, and most of the uncontrolled wells were capped. As a consequence, the decline in artesian head has slowed up, and in parts of the country the pressures have increased.

In Atascosa County, according to an investigation in 1944–45, a total of about 5.8 mgd. was escaping from uncontrolled flowing wells and was largely wasted, although some of it was used to supply artificial lakes for hunting and fishing or to maintain a flow in streams for watering stock during dry periods. The facts were published and the matter was discussed in detail with the Atascosa County Soil Conservation District, composed of a large group of

farmers. It is expected that the Board of Water Engineers, in cooperation with this group, eventually will be able to cope with the situation. It is impossible to accomplish much at the present time owing to the high cost and shortage of material.

It should be mentioned here that a part of the public indifference to the enforcement of the law against artesian waste is due to the cost and physical difficulties involved in bringing some of the flowing wells under control. Most of the waste occurs in areas where the artesian aquifers are many hundreds of feet beneath the surface, and the wells consequently are deep and costly. A large part of the uncontrolled wells are old and the casings are corroded, if not actually eaten through, by the action of the chemicals in the water. Any attempt to cap such wells without partially or completely recasing them may result in failure, as the water may escape through leaks and, by upward movement outside of the casing, reach the surface or overlying beds containing salty water. Occasionally repairs cannot be made and the only solution is to seal the defective well completely and drill a new one at a cost which the small landowner is not able to afford. It is difficult to see how anything can be done with such wells, unless the community is organized and prepared to assume a part of the cost of stopping the waste.

A recent investigation in Bexar County has shown that numerous wells in the area to the southwest of San Antonio are allowed to flow continuously, and that the water serves little useful purpose aside from supplying stock. The total flow of these wells amounted to about 10 mgd. in 1946, most of which was wasted. These facts were recently published by the board (1).

Nevertheless, the total waste from flowing wells in the state is small; in areas where the waste occurs, it amounts, on the average, to only a small percentage of the total discharge from the artesian aquifers in those districts.

During the past decade the desirability of establishing legal control over the development of ground water has repeatedly been given serious consideration by various groups in Texas. Proposals for such control have always met with more or less intense opposition, and the subject is now about as controversial as it has ever been. The State Board of Water Engineers has watched the progress of sentiment for and against legal control but has refused to take part in the movement, aside from furnishing factual data to all concerned. The board has always stood ready, and is even eager, to supply information. If laws are passed and the board is given a portion of the responsibility for enforcing them, it will endeavor to meet this duty.

Most of the farmers who irrigate from wells are against control. The feeling is growing, however, in the Winter Garden district and in parts of the plains region, that something should be done to check and guide the present unrestrained development, especially the excessive concentration of pumping. Whether this sentiment will develop in time to stop the disastrous overdraft, however, is problematical. It is said that Americans never lock the barn until the natural resource horse is stolen. The ground water horse has been stolen in other states and the same thing may happen in Texas, but the board will continue to

give warning when the horse thief of overdevelopment is approaching.

Special attention is to be given to the Winter Garden district and High Plains region in the program of ground water investigations during the current biennium, in order to compile more complete information than is now available regarding the practicable limits of pumping in different parts of each area.

Economical Irrigation Use

In closing, it should be said that most of the farmers in Texas who irrigate from wells are economical in the use of the water. According to the best information available, the average duty of pumped water is approximately 1 acre-ft. per acre in the High Plains, less than 1½ acre-ft. in the Winter Garden district of south Texas and about 2 acre-ft. per acre in the rice-growing areas of southeastern Texas. These figures may, however, be a trifle too low. They are now being checked by the Board in cooperation with the U.S. Soil Conservation Service and the Agricultural Division of Texas A. & M.

Acknowledgment

The major portion of the data relating to surface and ground water resources was furnished by Trigg Twichell, Asst. Dist. Engr., Surface Water Div., U.S. Geological Survey; and by Walter N. White, retired Dist. Engr., Ground Water Div., U.S. Geological Survey, now Sr. Hydraulic Engr., Texas State Board of Water Engineers.

Reference

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Water Laws of Oklahoma

By Clarence Burch

A paper presented on Oct. 13, 1947, at the Southwest Section Meeting, Amarillo, Tex., by Clarence Burch, Chairman, Oklahoma State Planning and Resources Board, Oklahoma City, Okla.

THE principle upon which the water laws of the State of Oklahoma is based is that running water in a natural stream—surface or subsurface—is not itself, *in specie* or as a substance, the subject of ownership, nor property in any sense of the word, but is in a class with the air. The water law (Sec. 11785, O.S. 1931) reads:

The owner of the land owns water standing thereon, or flowing over or under its surface, but not forming a definite stream. Water running in a definite stream, formed by nature over or under the surface, may be used by him as long as it remains there; but he may not prevent the natural flow of the stream, or of the natural spring from which it commences its definite course, nor pursue nor pollute the same.

It should be noted that water is divided into two classes, depending on whether or not a definite stream is formed by nature.

Private Ownership

The one case in Oklahoma dealing with the ownership of ground waters interpreted the statutes of ownership of water to follow the "American rule" of reasonable use. This was a clear-cut case between owners of land overlying a common ground water supply; one owner was attempting to withdraw water for distant use to the injury of the other, who had been making beneficial use of the common supply. The court stated that different rules apply to percolating waters and underground streams, and held that the waters in question were percolating. The statutory declaration that the landowner owns the water under his land not forming a definite stream was not, in the court's opinion, intended to convey such an absolute ownership as to result in unreasonable injury to his neighbor, who enjoys similar ownership.

The rule of reasonable use, applied here, means that each landowner is restricted to a reasonable exercise of his own rights in view of the similar rights of others. Exhaustion of a neighbor's ground water supply for the purpose of transporting water to distant lands is not such a reasonable use. This does not mean that there must be an apportionment of underground water between overlying landowners. The virtue of the rule of reasonable use lies in its application to concrete cases. Adequate laws governing the rate of withdrawal of underground water are needed, especially in areas where large quantities of water may be used for industrial purposes or irrigation. Of course, in time decisions by the court will outline the right to the use of underground water and define "reasonable" and "beneficial" use.

Public Water

Water running in a defined stream formed by nature over or under the surface, or a natural spring from which a stream commences its definite course, is public water subject to general appropriation. Such waters are administered by the Div. of Water Resources of the Oklahoma Planning and Resources Board, which is the successor of the State Engineer.

The riparian doctrine is apparently recognized to some extent in Oklahoma, but so far as a search of court cases discloses, the extent of the application of the doctrine, in its effect upon the rights of prior appropriators, has not been decided by the supreme court. The appropriation statute, however, has been before the court several times.

The appropriation statutes of Oklahoma declare that beneficial use shall be the basis, the measure and the limit of the right to the use of water. The supreme court has held beneficial use to be the determining factor in the right of use, and, notwithstanding the statute on private ownership, even the landowner is limited to reasonable use of water under his property.

Beneficial Use Priorities

Since beneficial use is the basis for the right to use water, it is necessary to place priorities or preferences upon uses that are beneficial. Only in the Conservancy Act, Sec. 13271, O.S. 1931, are such preferences set out. The order of preference for beneficial uses is based on the greatest need and the most reasonable use. The statute further states:

> Preference shall be given, first, to domestic and municipal water supply and no charge shall be made for the use of water taken by private persons for home and farm use, or for watering stock; second, to supplying water used in processes of manufacture, for the production of steam, for refrigerating, cooling and condensing, and for maintaining sanitary conditions of stream flow; third, for irrigation, power development, recreation, fisheries, and for other uses.

"Priority in time shall give the better right" is the rule for beneficial use of water. Priorities are determined under three separate divisions: first, those claiming beneficial use of water instituted prior to November 15, 1907; second, those claiming the right to beneficial use of water because they have made application to the State Engineer; and third, those making a beneficial use without application and commencing such use after November 15, 1907.

Hydrographic Survey

A hydrographic survey of a stream system is made to determine the average annual flow of the stream and its tributaries at various points, together with the fluctuation of flow, the amount of water being used beneficially, the date of commencement of use, the method and extent of such use and all other characteristics of the stream or its drainage necessary for the determination, development and adjudication of the water supply. These surveys form the basis for the determination of rights to the use of water for beneficial purposes.

The State Engineer is directed by statute to make hydrographic surveys and investigations of each stream in the state, and the source of its water supply, and is to obtain all factual data necessary for the adjudication of rights. He is further authorized to cooperate with federal agencies in similar surveys and undertakings and in the construction of works for the

development and use of the water supply of the state, expending such moneys as are available to his office. In connection with the making of a hydrographic survey, he may accept the results obtained by agencies of the federal government.

A hydrographic survey has been held prerequisite for the issuance of permits by the State Engineer for the construction of works to appropriate water for beneficial use. Such a survey was held by the court to be necessary before the State Engineer can grant a valid permit authorizing the appropriation of the water of a stream to the exclusion of individuals owning irrigable land through which the stream meanders.

Adjudication and Decree

Upon the completion of a hydrographic survey of any stream system, the State Engineer is required to deliver to the Attorney General a copy of the survey, together with all other necessary data for the determination of all rights to the use of water from that stream system. The Attorney General is instructed by statute to enter suit, within 60 days after receiving the hydrographic survey, on behalf of the state for the determination of all water rights.

If the water user starts the court proceedings, the Attorney General shall not be required to bring suit but must intervene on behalf of the state if requested to do so by the State Engineer.

State Control of Louisiana Water Resources

By John E. Trygg

A paper presented on Oct. 13, 1947, at the Southwest Section Meeting, Amarillo, Tex., by John E. Trygg, Chief, Water Supply and Waste Disposal Section, Louisiana State Dept. of Health, New Orleans, La.

To understand the legislation required by Louisiana for the control of its water resources, their status should first be briefly reviewed.

Louisiana has an abundance of ground water, most of which is of good quality, both bacteriologically and chemically. In addition, there are many sources of surface water, the principal one being the Mississippi River. Water from most of these surface sources, however, requires considerable treatment if it is to be used as a domestic supply. The relatively high temperature of the surface water also makes its use for industrial cooling impracticable, but there is a possibility that industries may use surface water for recharging aquifers during the winter months. It is understood that oil industries in the Baton Rouge area are giving consideration to such a project.

The majority of domestic water supplies utilize ground water sources, with the exception of a section along the lower Mississippi River and the lower southern portions of the state from the Mississippi River west about 125 miles. Monroe and Shreveport, located in the northern part of the state, also use surface water.

Louisiana has experienced great industrial growth in the past ten years, particularly in the oil industry, and the water requirements for industrial use have increased proportionately. Oil industry wells in the vicinity of Baton Rouge have delivered as much as 70 mgd. (1). Paul Jones, of the U.S. Geological Survey, estimates that, from a relatively small area within a 4,000-ft. radius, 50 wells produce a total of approximately 45 mgd. It is estimated that only 25 mgd. was being used ten years ago by industries in this area.

A number of industrial wells in the Baton Rouge area tap the same strata from which water for the city itself is obtained. Although the wells serving Baton Rouge originally flowed at the surface with a pressure of approximately 40 psi., they must now be pumped; in fact, in the last few years the pump bowls have had to be lowered a number of times.

Industries in the Lake Charles area are estimated to be using approximately 50 mgd., compared with 12,000–15,000 gpd. ten years ago. The Lake Charles area overlies a particularly good aquifer, and industrial demands have not appreciably affected municipal supplies or injured the water-bearing strata.

In New Orleans and vicinity it is estimated that industries pump 50 mgd. from wells, but this does not infringe on domestic supplies, as little ground water in this area is satisfactory for domestic use.

In northern Louisiana, the paper industries are users of large volumes of water. At Hodge about 14 mgd. is used, and at Springhill the figure is approximately 20 mgd. These are old established mills, and there has apparently been no increase in pumpage in the last ten years.

Agriculture seems to have made the most serious inroads on the resources in any one section of the state. It is estimated that in 1946, in 13 parishes in the southwest portion of Louisiana, 586,178 acres of land were planted in rice. Ordinarily about 2.2 ft. of water must be added to supplement the rainfall (2). In 1946 248,040 acres of rice were irrigated by wells (3); and in 1947, approximately 263,000 acres. The total water used for irrigation from wells in 1947 is estimated to be in excess of 500,000 acre-ft., or a daily average of 2,770 acre-ft. during the growing season.

This rice area is in the extreme southern portion of the state near the Gulf of Mexico, and salt water intrusion is a definite possibility. In fact, at the present rate of withdrawal of ground water, the amount of recharge is not sufficient to raise the water level in the central part of the irrigation area to a height which will produce a head sufficient to prevent the intrusion of salt water (4).

Louisiana does not now have organized control of its water resources, although several state agencies independently exercise some jurisdiction over the supply.

Stream Control Commission

The State Stream Control Commission was created by Act 367 of the legislature in 1940 and amended by Act 199 in 1942. In brief, this act provides for a commission to be composed of five members: the Commissioner of Conservation, the President of the State Board of Health, the Commissioner of Agriculture and Immigration, the Executive Director of the Department of Commerce and Industry and the Attorney General of the state, or their duly authorized representatives. Section 3 provides:

> That the Stream Control Commission shall have control of waste disposal, either public or private, by municipalities, industries, public or private corporations, individuals, partnerships, associations or any other entity, into any of the lakes, rivers and streams of the State or any tributaries or drain flowing into any of such lakes, rivers, or streams, and into any of the coastal waters of the Gulf of Mexico within the territorial jurisdiction of the State of Louisiana, for the prevention of pollution thereof tending to destroy fish life, or to be injurious to the public health or the public welfare or to other aquatic life or wild or domestic animals or fowls.

The Stream Control Commission is not an administrative agency. Section 5 of the act provides:

> That the Department of Conservation of the State of Louisiana shall enforce and administer the provisions of this Act and the rules, regulations and orders of the Commission; and the agents and enforcement officers of the Department of Conservation shall be ex-officio agents and enforcement officers of the Commission.

Public Works Department

The State Department of Public Works, created in 1940, has done considerable work in the promotion of water use and in control projects (5), particularly in flood control and drainage. This department recognized the

need for a study of water resources in the state; and, after a preliminary investigation in 1943, a program was formulated to obtain the necessary information for a comprehensive report on the status of both ground and surface water resources. The program has been carried out in cooperation with the Department of Conservation and the Ground Water Division of the U.S. Geological Survey, but a final report on this study has not yet been released.

It is understood that the departmental budget for 1949 and 1950 includes funds for the preparation of a final report on ground water in the rice-growing areas of southern Louisiana.

Health Department

The State Department of Health also exercises certain controls over water resources. The act creating the department authorized it to prepare a State Sanitary Code which would contain rules, regulations and ordinances —of a general as well as a specific nature—for the improvement and amelioration of the hygienic and sanitary conditions of the state.

Under the provisions of the code, the department is given authority to prescribe the treatment required for sewage if the volume of flow and the conditions of the receiving stream are unsatisfactory for the disposal of the sewage or other waste material by dilution. The code further prohibits the discharge of industrial wastes into any lake, pond, stream or underground water stratum, or into any place from which the wastes may flow, or be carried, into a source of a public water supply.

The department exercises little control over ground water except to require the proper construction of wells used as a source for a public water supply, in order to prevent contamination of the water in pumping and to prevent any possible pollution of the water-bearing strata from surface contamination. For this purpose, the code also provides authority for the department to require that all abandoned wells be sealed.

Proposed Legislation

To meet the long-felt need for the integrated control of water resources in the state, House Bill 870 was introduced in the 1944 legislature, proposing a constitutional amendment which would create a Water Control Authority and authorize the legislature to appropriate funds for it and define its duties. This bill provided that the Louisiana Water Control Authority would consist of seven men appointed by the governor for terms concurrent with his own; one member each to be recommended by the heads of the Department of Health, Agriculture and Immigration, Commerce and Industry, Public Works, and Justice; and one member each to be recommended by the Minerals Division and the Division of Wild Life and Fisheries, both of the Department of Conservation.

The accompanying House Bill 871 recognized the Louisiana Water Control Authority as created by House Bill 870 and prescribed the duties of the authority, defining its powers and jurisdiction. The authority was granted the power:

> To make a study of water resources of the State, both surface and subsurface. . . .
>
> To make, amend or rescind after public hearing such rules or regulations and

orders as it may deem to be in the best interest of the people of the State. . . .

To seal off, or require the sealing off, of any abandoned artesian wells in the sand from which any subsurface water flows.

To regulate the diversion of surface waters from lakes, rivers, streams, bayous or natural drains, and to regulate the extent to which such waters may be retarded in their natural flow. . . .

To prohibit by rule or regulation the discharge of waste disposal into surface waters or subsurface or ground waters of the State. . . .

These bills, which were sorely needed, were defeated in the 1944 legislature, largely through the influence of industrial interests.

Louisiana has not yet experienced too many problems with its water resources. It is, however, essential that legislation for the control of water resources be passed to forestall inevitable trouble and possible intervention by the federal government.

Legislation such as House Bills 870 and 871 is certainly needed in the state. Whether or not a bill to regulate the control of Louisiana's water resources will be introduced in 1948, or whether or not it would receive favorable consideration, is problematic.

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Pontiac Recalcining Plant

By Bernal H. Swab

A paper presented on September 20, 1947, at the Michigan Section Meeting, Bay City, Mich., by Bernal H. Swab, Engr., Jones & Henry, Toledo, Ohio.

ONE of the major problems encountered in the design of the water softening additions to the Pontiac Water Filtration Plant was the provision for the disposal of the carbonate sludge to be produced by the lime softening process.

The present filtration plant was constructed over 25 years ago and, for several reasons, has never been operated except on an experimental basis. The proposed improvements to supply softened water will consist of the remodeling of the existing filter plant and the addition of flocculating and settling tanks and a chemical building for the softening process.

The new plant was designed to treat well and surface water, both of which are available. Typical analyses of the water from the two supplies are given in Table 1. The design contemplates an average daily consumption of 10 mgd. and a maximum daily consumption of 17.5 mgd. To permit the treatment of water of widely varying characteristics, the maximum flexibility was provided in the plant layout. The plant includes two sets of flocculation and settling tanks which can be operated in parallel or series, and provision was made for split treatment if desired.

Maximum employment of lime for softening would occur if the well water supply were used. Approximately 2,200 lb. of 88 per cent calcium oxide (quicklime) would be needed to reduce each milion gallons of water to 70 ppm. of hardness, or a total of 22,000 lb. per day at the average design consumption rate. Because approximately 2.5 lb. of sludge solids can be expected for each pound of lime added, the average weight of dry carbonate sludge solids produced per day will be almost 28 tons. The problem of satisfactory disposition of this great quantity of sludge finally led to the decision to incorporate provisions for drying the sludge and recovering the lime.

Other means of disposal were investigated—such as discharge into the Clinton River, storage in lagoons on wasteland and discharge to the sewage treatment plant—but none of these alternate methods proved to be feasible for extended periods of time. In order to provide for emergency operation in case of failure of mechanical equipment, provision was made in the design to dispose of the sludge into the river or the sewers, but it is not anticipated that this will be necessary except for short periods.

The recovery of lime from carbonate sludge has been practiced for years in the pulp and paper industry. The Southend Water Plant at Langford, England (1), has used this process successfully for over eighteen years. Valuable experiments have been performed by Aultman (2), Pedersen (3), Dorr (4) and others.

Plant Operation

The equipment proposed for the Pontiac plant will provide for three principal stages of operation: (1) dewatering, classifying and rejecting the greater portion of the magnesium and other impurities by means of continuous centrifuges; (2) drying in the Raymond Flash Drying System *; and (3) recalcination by exposing the dried material to a temperature of approximately 1,900°F.

A rotary kiln was considered as drying and recalcining equipment but was discarded in favor of the Raymond system, which appeared more applicable to this installation. A somewhat different type of calcining furnace, called the FluoSolids system,† was not sufficiently developed at the time of design to receive consideration. A trial installation is under construction from which information should be available early in 1948. The Raymond and FluoSolids systems have similar space requirements and both must be preceded by facilities for dewatering and drying. When the time comes for the actual construction of the Pontiac plant, it is expected that alternate bids can be taken to include either of these types of calcining.

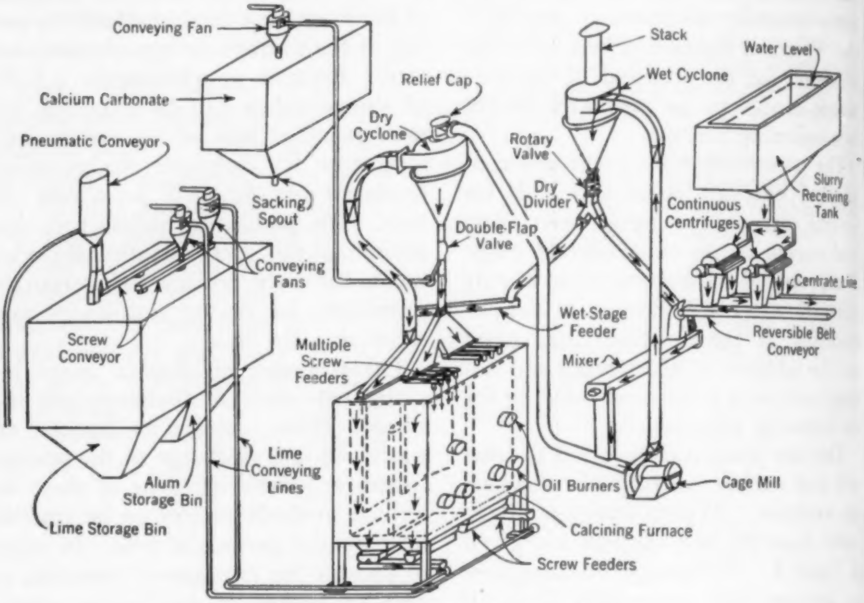

Fig. 1. Pontiac Recalcining Plant

A diagrammatic representation of the Pontiac Recalcining Plant is shown in Fig. 1. Carbonate slurry from the settling tanks, expected to contain approximately 15 per cent solids, will be pumped to the slurry receiving tank. The pumps will be automatically con-

* Manufactured by the Raymond Pulverizer Div., Combustion Engineering Co., Inc., Chicago. For additional details concerning the system, see the Discussion following this article (p. 466).

† For a description of this system see the Discussion following this article (p. 465).

trolled to maintain a uniform level in the receiving tank within close limits. The receiving tank will be equipped with a slow-speed stirrer to maintain a uniform consistency.

From the receiving tank the slurry will flow to two continuous centrifuges, where excess water and a large per-

over a belt conveyor to a pugmill mixer. There it will be mixed with previously dried solids to form a material of a consistency and moisture content satisfactory for flash drying.

From the mixer the material will pass to the flash drier, composed of a cage mill and blower, in which the par-

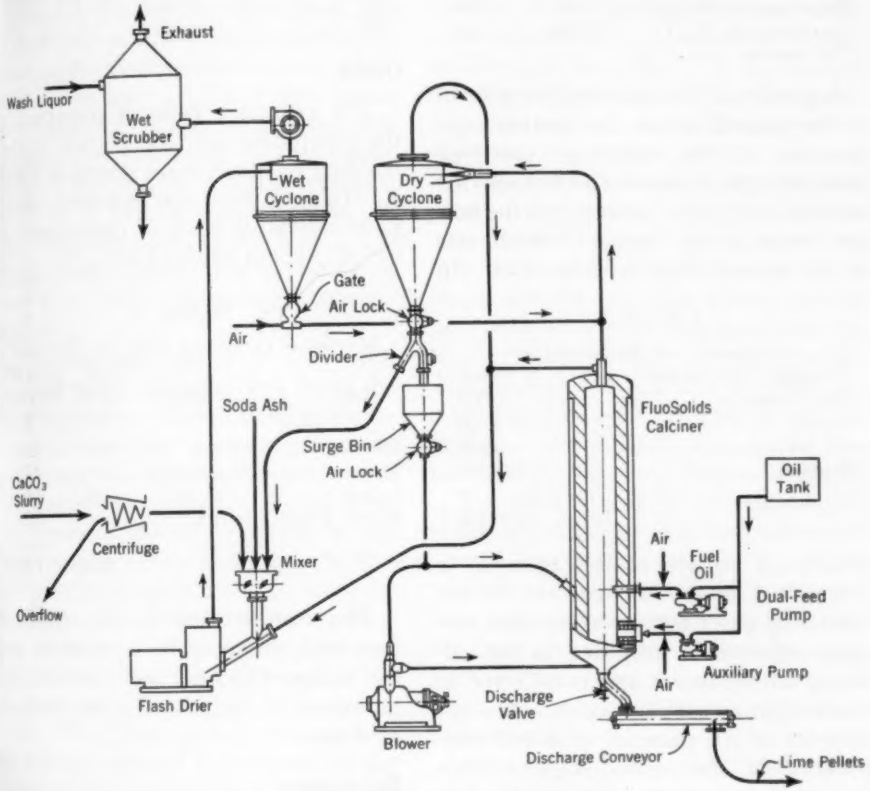

FIG. 2. FluoSolids System Flow Diagram

centage of the magnesium hydroxide and other impurities will be rejected and discharged into the sanitary sewer. (No difficulty will be encountered because of the flocculant characteristics.) Centrifuge cake, containing approximately 65 per cent solids which consist of about 90 per cent calcium carbonate as $CaCO_3$, will be discharged

ticles are subjected to brief but effective contact with the hot gases from the forced-draft, oil-fired recalcining furnace. The material is carried in the current of hot gases and separated from the gas and vapor in the first stage or wet cyclone. At this stage the carbonate sludge contains about 7 per cent moisture.

TABLE 1

Pontiac Water Analyses

	Well	Surface
	ppm.	
Solids	370	176
Silica	10	6
Carbon dioxide	30	*
Iron	1	*
Calcium	74	46
Magnesium	30	18
Bicarbonates as $CaCO_3$	362	190
Hardness as $CaCO_3$	308	185

* No analysis.

A portion of this material is returned to the pugmill mixer for further conditioning of the incoming centrifuge cake, and the remainder is transported by chute and screw conveyor to the hot-gas outlet of the furnace, which acts as the second stage or final drier. In practice, a portion of this material is not picked up by the current of hot ascending gases but drops into the furnace, where it is subjected to the calcining temperatures and is collected at the bottom as calcium oxide. The remainder of the material is stored temporarily in the second-stage cyclone and withdrawn at controlled rates through the front portion of the furnace, where it passes through the heated zone and comes to rest in the bottom of the furnace as calcium oxide.

TABLE 2

Equipment and Building Cost

Calcining Equipment	$ 96,000
Centrifuges	26,000
Piping	4,000
Oil Storage	4,500
Building	110,000
TOTAL	$240,500

Calcium oxide from the furnace is transported by means of water-cooled screw conveyors and pneumatic conveyor lines to the storage bins, from which it is fed by lime feeders and slakers to the raw water for softening.

Provision is made for the withdrawal and disposition of dried calcium carbonate from the system. It will also be possible to dispose of the centrifuge cake by reversing the belt conveyor under the centrifuge and discharging the cake into trucks outside the building.

Costs

The estimated costs of constructing the equipment and the portion of the building to house it are shown in Table 2. Table 3 gives the estimated maximum operating costs of producing one ton of calcium oxide (CaO).

TABLE 3

Maximum Operating Cost per Ton CaO

Item	Quantity	Unit Cost $	Cost per Ton CaO $
Oil	85 gal.	0.05	4.25
Power	70 kwhr.	0.01	0.70
Labor	1.25 hr.	1.20	1.50
Fixed Plant Charges			1.50
		TOTAL	7.95

The cost per ton of the recalcined lime will prove to be economical and the designed system will eliminate the nuisances of the several other methods of disposal.

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Discussion

By A. J. Fischer

Development Dept., The Dorr Co., New York.

The paper by Bernal H. Swab on the Pontiac Recalcining Plant is both interesting and timely. As the author points out, the reburning of lime has been widely practiced for a number of years in the heavy chemical and paper pulp industries. In the water works field, however, there is an economic problem involved, since it is generally accepted that it does not pay to reburn less than 25 tons of calcium oxide per day in conventional rotary kilns. On this basis, lime reburning would be of interest to only a few large municipalities.

This economic picture has been changed within the past few years by the introduction of new calcining methods which promise to reduce fuel requirements and high maintenance costs common in rotary units. One of these new methods involves the use of the Dorr Co. FluoSolids Calciner. In this unit previously dried sludge may be effectively reburned in fluid suspension, with the production of a pelletized form of lime that is ideally suited for re-use in the softening process.

The FluoSolids principle was first successfully reduced to practice by the Standard Oil Development Co. in the catalytic cracking of crude oil. It has since been applied commercially in the metallurgical field for the roasting of ores. A large-scale pilot plant unit for burning limestone has also been successfully operated.

As shown in Fig. 2, the sludge pumped from the plant settling unit is first delivered to a centrifuge for preliminary dewatering, then mixed with a slight amount of soda ash and some previously dried sludge and finally dried in a Raymond flash drier.

The bone-dry solids are fed to the FluoSolids kiln (Fig. 3). The feeding point is the active fluidized zone where $CaCO_3$ is being converted to CaO. Fuel oil sufficient to maintain a temperature of about 1,750°F. is injected directly into the bed. The air necessary to support combustion and to maintain the bed in a fluid state is injected through the conical perforated plate at the bottom. As pellets in the active calcining zone grow in size so that they are no longer maintained in suspension by the hot gases passing up through the bed, they drop into the bottom cone to the discharge point. The passage of the air through the settled pellets serves to preheat the air and cool the finished lime. The finished pellets discharge at about 300°F.

The chief advantages of this calciner are its compactness and low installation costs. Operating costs are also very small because of the fuel economy and low maintenance requirements resulting from the absence of moving parts. Furthermore, the pelletized form of lime produced results in relatively dust-free operation.

Although to date only small-scale pilot plant tests have been run on water-softening sludge, they have demonstrated the feasibility of applying the FluoSolids principle in this field. A large-scale test unit is now under construction and should be placed in operation in 1948. The small-scale tests have established basic design data on area requirements and the need for adding soda ash to the feed, as well as

the necessity for starting up with a bed of "seed" pellets. The large-scale experiments on limestone, using a 5-ft. diameter kiln, have demonstrated the fuel economy of the system and such other vital points as the method of feed and fuel injection, lime discharge methods and so forth. With this information at hand, it is felt that it is only a matter of time until the FluoSolids Calciner is fully developed and commercially available in the water softening field.

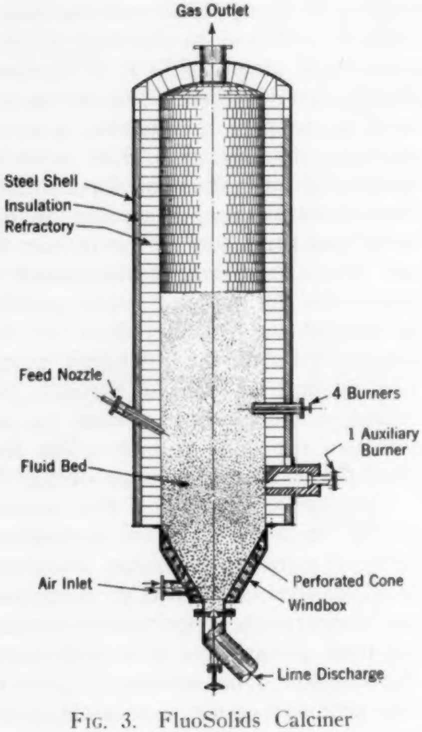


FIG. 3. FluoSolids Calciner

C. W. Gordon

Mgr., Flash Dryer Div., Combustion Engineering Co., Inc., Chicago.

It has been the privilege of the writer to develop—in cooperation with H. V. Pedersen, Supt. and Gen. Mgr., Marshalltown, Iowa, Water Dept.—a rapid, modern and efficient flash drying and calcining system at the treatment plant in Marshalltown. This development has required several years for its successful completion, and the various steps will not be detailed here. The actual operation has resulted in many problems, but these have been solved. During the process of development, a number of changes were made in the equipment. As soon as feasible, Supt. Pedersen plans to rebuild his plant on a permanent basis.

The C–E Raymond Flash Drying System is well known to industry for the rapid drying of materials in the fine to granular form. The precipitated calcium carbonate in water softening sludge is very finely divided and is readily dried in the flash drying system. The complete conversion of dewatered centrifuged cake to a dried and preheated powder requires only a few seconds. It was therefore quite natural to think in terms of a flash calcining system in which the decomposition of the carbonate could also be accomplished in a few seconds. The flash drying and preheating system entails no unusual problems. The design of the calcining furnace, on the other hand, involved many difficulties and several years of development.

Because the calcining furnace serves the dual function of decomposing the carbonate and collecting the finished lime, the design and proportioning of the various pieces is quite important. The location of the oil burners is also of major importance, in order that complete calcination may be accomplished in a few seconds.

The water softening sludge at Marshalltown has a theoretical lime content of approximately 84 per cent. Th

lime content of the recalcined material has averaged 80 per cent or better in daily operation. The recalcined lime has all been re-used either as the entire lime feed to the plant, or for supplementing the raw lime supply. Coagulation with the recalcined lime has been excellent.

The water flow at Marshalltown varies from 2 to 4 mgd., averaging approximately 3.5 mgd. The plant now in operation has sufficient capacity to calcine the daily sludge production in one eight-hour shift. The furnace is well insulated and is brought up to operating temperature in 30–45 minutes. A temperature of 1,800°–1,900° F. is maintained at the top of the first pass in the calcining chamber, while the temperature of the gases leaving the oil burners and first contacting the preheated carbonate is of the order of 2,800° F. and that leaving the calcining furnace varies between 1,200° and 1,400° F. These spent gases are used in the flash drying system to dry and then preheat the calcium carbonate.

The flash drying system is of the two-stage, counterflow type. This design is used for maximum heat recovery and also for reduction of the vent loss from the system to a minimum. The only vent from the entire system is in the wet stage. This stage serves the dual purpose of predrying the carbonate and wet-washing the vent gases. The temperature of the gases leaving the flash drying system is 160° F., compared with 600°–800° F. for gases leaving the most modern rotary kilns. Since the gases enter at about 2,800° F., it will be seen that this new flash drying and calcining system operates with maximum thermal efficiency.

After perfecting the mechanical details of the system at Marshalltown, a study was made of the fuel economy. As the operating staff has become more familiar with the equipment, and as certain refinements have been made in the design, the fuel consumption has steadily decreased. With the intermittent operation at Marshalltown, it has been possible to produce a ton of high-quality finished lime burning 70 gal. of fuel oil containing 138,000 Btu. per gallon—or, expressed differently, 9,660,000 Btu. per ton of lime. Continuous operation would no doubt result in a further reduction in this figure. The power consumption for this operation is nominal, averaging 60 kwhr. per ton of finished lime.

The flash drying and calcining system at Marshalltown has been completely successful in producing high-quality lime at a price which justifies its operation in a water treatment plant of such small capacity.

The design of the Pontiac recalcining plant, so ably described by the author, follows the final development at Marshalltown in every respect. The fuel and power guarantees recorded by the author are now somewhat conservative, in the light of recent Marshalltown operating data. There are, however, several factors which affect the operating economy, and these will undoubtedly vary with different water types. It is therefore felt that guarantees should be conservative, at least until experience is obtained with several types of water softening sludge.

Two New Total Alkalinity Indicators

By Michael Taras

A contribution to the Journal by Michael Taras, San. Chemist, Dept. of Water Supply, Detroit.

RECENTLY two indicators of the disazostilbeneaminedisulfonate series have been suggested for the total alkalinity titration of water (1). One of these undergoes an orange-red to bluish-purple transition, while the second changes from a deep yellow to a muddy hue.

Among the advantages claimed for these dyes is that their greatest color responses occur in a pH range where methyl orange fails to function. Moreover, the color responses are of an order which can readily be reproduced by most analysts.

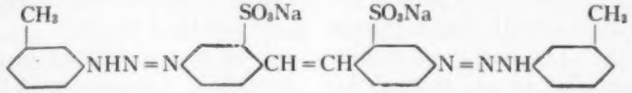
As Cooper (2) and other investigators have shown, methyl orange is sometimes unsuitable for the determination of low alkalinities. Schroeder (3) states that the "phenolphthalein-methyl orange titration is not accurate in boiler-water solutions whose concentrations of carbonates are below 60 ppm. At 30 ppm. of carbonate the maximum possible error which may be expected is 26 per cent." This error arises largely from the fact that the first perceptible color change with methyl orange occurs at a pH of 4.6. According to Cooper (2), the pH prevailing at the end-point of an acid-carbonate titration of 30 and 50 ppm. should be 4.85; for 70 and 100 ppm. the pH should be 4.75; for 150 ppm., a pH of 4.6; and for 250 ppm., a pH of 4.5. Thus, methyl orange under the most favorable circumstances is only justified for alkalinities in excess of 150 ppm. Many individuals possess imperfect color sensibility, however, rendering impossible the proper identification of the faint orange characteristic of methyl orange at a pH of 4.6. Often the sample is overtitrated to a deeper orange representing a pH of 4.5 or 4.4, with a consequent sacrifice in accuracy.

Other considerations also contribute to the difficulty of the titration. Properly executed, the acid-carbonate titration is a difficult determination, for at no point during the titration is there a precipitate drop in pH. The most pronounced drop occurs at the end-point but is of a comparatively minor magnitude.

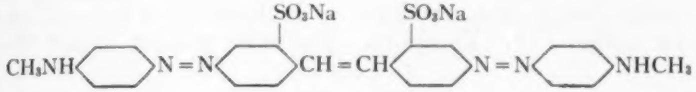
A typical titration curve involving a strong acid and a strong base shows a marked pH drop at the end-point. The drop may be likened to a vertical cliff, denoting the end-point at a glance. Contrasted with this well-defined drop, the acid-carbonate curve resembles a toboggan slide. To ascertain the end-point correctly it is necessary to analyze every increment in the curve by the processes of calculus.

As a result, a demand exists for indicators registering a color change in the pH region immediately above 4.6. A number of dyes of the stilbene group have been found which answer the purpose. In addition to the two indicators reported elsewhere (1), two others with striking transitional prop-

erties may be applied to the determination of total alkalinities. The new indicators have the following structural formulas and technical names:



disodium 4,4′-bis(*m*-tolyltriazeno)-2,2′-stilbenedisulfonate, hereafter referred to as indicator I, for the sake of brevity; and



disodium 4,4′-bis(*p*-methylaminophenylazo)-2,2′-stilbenedisulfonate, hereafter called indicator II.

The dyes give a yellow to purple and an orange to purple color respectively. Unhappily, the newness of the indicators explains their current unavailability in the chemical market. On this account, laboratory synthesis must be undertaken if experimental quantities are to be prepared.

Indicator Properties

The disazostilbeneaminedisulfonate dyes are notable for one property absent in most common indicators; that is, insolubility in the transitional and acid color area. This property is a definite aid in locating the end-point. Frequently the settling-out process is visible as the titration progresses toward its logical conclusion. Specks of the dye may be seen floating on the surface of the solution; or, if the titration is performed in a porcelain casserole, successive rings of the dye become adsorbed on the white walls. Permitted to stand, the acidified dye eventually precipitates out. Consequently, the stilbene dyes are unsuitable for the colorimetric measurement of pH, particularly if a series of permanent standards must serve over extended periods of time.

The property of insolubility is apparent in varying degrees among the individual members of the stilbene family. For example, indicator II gives rise to purple specks in the final stages of the titration. Indicator I, on the other hand, yields primarily a color change at the end-point and only very slight precipitation. Waters with a high salt content doubtless would hasten the precipitation by virtue of a salting-out action.

Buffer solutions formed from 0.2 *M* sodium dibasic phosphate and 0.1 *M* citric acid (4) were used to determine the effective pH interval of the indicators.

Indicator I exhibits a yellow hue in the alkaline range. A brown shade appears at a pH of 5.0, modulating to mauve at a pH of 4.8 and purple at a

TABLE 1

Indicator Color Changes

pH	Indicator I*	Indicator II†
5.4	yellow	orange
5.2	pale brown	brown
4.8	mauve	
4.6	first evidence of purple	
4.4	deeper purple	
4.0	deep purple	

* Six drops of 0.1 per cent indicator added to 100-ml. buffer solution.

† Ten drops of 0.1 per cent indicator added to 100-ml. buffer solution.

pH of 4.6. The purple deepens as the pH declines toward 4.0 (*see* Table 1).

The alkaline color of indicator II is orange, which changes to brown at a pH of 5.2. A mauve color enters the system at a pH of 4.8, turning to purple at a pH of 4.6. The purple intensifies with the depression of pH toward 4.0 (*see* Table 1).

Preparation

The preparation of the disazostilbeneaminedisulfonate dyes has been reported at ample length in a previous article by the author (1). Therefore, a brief outline of the procedure for synthesizing the two new dyes described in this study should suffice here.

Indicator I is prepared by the tetraazotization of 9.25 g. (0.025 *M*) of 4,4′-diaminostilbene-2,2′-disulfonic acid, Eastman Kodak T4613, with 3.45 g. (0.05 *M*) of cp. sodium nitrite in ice and 25 ml. of concentrated hydrochloric acid, at a temperature below 5°C. After standing for two hours, the supernatant liquid is withdrawn and the diazonium slurry added with stirring to the coupling solution, which consists of 10 ml. (0.09 *M*) of *m*-toluidine, Eastman Kodak 862, in a 20 per cent acetic acid solution. The coupling reaction is carried out at room temperature for 1½–2 hours.

The dye is filtered by suction and air-dried. Conversion to the disodium salt is accomplished by grinding a carefully weighed amount of the dry powder with the calculated volume of 0.05 *N* sodium hydroxide and diluting to the proper concentration.

Indicator II is prepared in precisely the same manner except that 10 ml. (0.09 *M*) of monomethylaniline, Eastman Kodak 353, is substituted as the coupling amine. A 0.1 per cent aqueous solution of indicator II possesses a deep red color.

Indicator I is best prepared in an acetone solution. A 0.1 per cent solution of the indicator in acetone possesses an orange-red color.

TABLE 2

Titration of Synthetic Sodium Carbonate Solutions *

Total Alkalinity Added	Indicator I		Indicator II	
	Total Alkalinity Found	Deviation	Total Alkalinity Found	Deviation
		ppm.		
20	20	0	22	+2
50	51	+1	51	+1
80	80	0	80	0
100	100	0	100	0
200	200	0	200	0
250	250	0	250	0
400	397	−3	401	+1
500	496	−4	501	+1

* Each result represents the average of five titrations.

Experimental Details

The impossibility of isolating calcium and magnesium bicarbonates in a solid state makes it extremely difficult to

reproduce a standard natural water in the laboratory. In alkalinity measurement this situation poses no problem, for sodium carbonate provides an adequate substitute. This substitution is tenable on the ground that the total alkalinity titration determines the concentration of bicarbonate ion, and sodium carbonate supplies this ion in its purest weighable form. Accordingly, solutions of analytical-reagent grade sodium carbonate were employed as the reference standard throughout these experiments.

A stock solution of sodium carbonate was prepared in 0.1 N strength, a 1 : 10 dilution being used for alkalinity concentrations up to 500 ppm. All dilutions were made with distilled water from which carbon dioxide had been thoroughly expelled by boiling. The final volume before titration was always 100 ml.

The 0.02 N sulfuric acid was standardized electrometrically against 0.01 N sodium carbonate by the differential method.

Titrations were carried out in Erlenmeyer flasks resting on a white background. Six drops of indicator I and 10 drops of indicator II were required for every 100 ml. of sample volume. Cooper's findings (2) served as the guide by which the titrations were conducted, a mauve color being selected as the end-point for alkalinities below 150 ppm. and various shades of purple above 150 ppm. The results of these titrations are shown in Table 2.

To test the adaptability of the indicators to natural conditions, a series of titrations were performed on Detroit raw and finished water. A 100-ml. sample was taken for analysis and the results of the tests are recorded in Table 3.

TABLE 3

Titration of Detroit Raw and Tap Water

Total Alkalinity Found by Electrometric Method	Indicator I		Indicator II	
	Total Alkalinity Found	Deviation	Total Alkalinity Found	Deviation
ppm.				
65	65	0	65	0
70	70	0	71	+1
72	73	+1	72	0
75	76	+1	76	+1
78	78	0	78	0
79	79	0	79	0
80	81	+1	81	+1
82	82	0	82	0

Conclusions

With considerable training the human eye is capable of distinguishing minute color transformations, but the habit must be assiduously cultivated. A transition from a lighter color to a deeper hue, such as from yellow to purple, is obviously easier to follow than a change occurring among neighboring tints like yellow and orange. The stilbene indicators serve a valuable purpose in providing the vivid contrast needed for instantaneous per-

ception. Moreover, the point of sharpest transition is at the opposite end of the spectrum; that is, at the first definite change to purple. Fortunately, the equivalence pH of the dilute bicarbonate-acid system lies within this critical transitional zone.

The light-to-dark color change constitutes another notable advantage, because colored solutions may be titrated with more accuracy than heretofore possible. A solution in which color is present before titration greatly modifies the color change at the end-point. To illustrate: a color change from yellow to faint orange is practically invisible in a yellow or amber solution. Even a change from yellow to deep red is difficult to trace in the same environment, since the transition appears as a yellow-to-orange change. And the color change is not the sole factor involved in a colored titration. It is of the utmost importance that the modified color change develop over a suitable pH interval. Methyl orange suffers from the fact that the color change is vague and hard to reproduce in colored solutions; and, above all, the modified yellow-to-orange change takes place in a pH region productive of excessively high results.

The indicators reported in this paper, on the other hand, fulfill the special demands of colored titrations. The chromatic changes are such that they overcome the original color and occur at a pH designed to assure both precision and accuracy.

Tables 2 and 3 reveal the accuracy to be expected with the stilbene indicators in titrations performed in the absence of color. Almost perfect accuracy is possible with the two indicators in synthetic carbonate solutions containing up to 250 ppm. alkalinity. Above 250 ppm., indicator II is a trifle more accurate, but the sharper end-point afforded by indicator I tends to compensate in some measure for a slight negative error. Surface waters of low alkalinity, as at Detroit, present no difficulty for either indicator.

In the main, the two new indicators are eminently acceptable for the titration of total alkalinity as conducted in the typical water treatment plant.

References

1. Taras, Michael. New pH Indicators for Determination of Total Alkalinity in Water. Anal. Chem., **19**:339 (1947).
2. Cooper, S. S. Mixed Indicator Bromocresol Green-Methyl Red for Carbonates in Water. Anal. Chem., **13**:466 (1941).
3. Schroeder, W. C. Errors in Determination of Carbonate in Boiler Waters. Anal. Chem., **5**:389 (1933).
4. McIlvaine, T. C. A Buffer Solution for Colorimetric Comparison. J. Biol. Chem. **49**:183 (1921).

Abstracts of Water Works Literature

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (British); C.A.—Chemical Abstracts; Corr.—Corrosion; I.M.—Institute of Metals (British); P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (British).*

BOILERS AND FEED WATER

Boiler Scale Removal by Chemical Cleaning. B. J. Cotey. Power Plant Eng. **50**:8:75 (Aug. '46). Removal of boiler scale difficult because acid removing scale also reacts with metal. Therefore necessary to use inhibitor, best type depending on concn. and type of acid and process employed. Carbonates and phosphates easily removed, silicates and oxides more difficult, and pure silica or pure sulfate almost impossible. Oil requires special treatment. 2 general methods of cleaning boilers: (1) fill-and-soak, (2) pump circulation. Cleaning procedure: fill unit with recommended solvent, allow to soak or circulate until all scale disintegrates, drain, fill with water, drain, fill with boiler neutralizing compd., boil and then drain. Filling of boiler and heating of soln. described in detail. Photo and diagram.—*Corr.*

Silica Scale Prevention. Ray McBrian et al.. Am. Ry. Eng. Assn. Bul. 469, p. 74 (Nov. '47). With locomotive boiler pressures increasing to over 250 psi., formation of silica scale has resulted in damage to side sheets and fire boxes from localized overheating. Methods used for removal of silica: (1) absorption with alumina floc and (2) chem. reaction with Mg at high temp. New methods being tested: (1) absorption of silica by rusting of Fe in form of cast-iron borings and (2) demineralizing plants after prelim. treatment with NaF.—*R. C. Bardwell.*

Silica Deposits in Steam Turbines From Softening of Make-up Through Natural Zeolite. R. F. Owens. Combustion **19**:37 ('47). In steam turbines operating at pressures of 600 psi. or less, when greensand used as water softener, SiO_2 deposits found; samples from 3 plants contained, resp.: SiO_2—93.89, 88.10 and 88.01; Fe_2O_3—2.56, 6.00 and 4.20; SO_4—1.40, 0.42 and 3.46; Cl—0.37, 1.27 and 0.96; OH—none, none, none; CO_3—none, 0.42 and none; P_2O_5—none, 0.49 and 0.94; CaO—0.29, none and 0.12; MgO—0.96, none, none; Na_2O—1.01, 1.65 and 1.42. Decreasing H-ion concn., decreasing dissolved solids, and use of Mg salts in boiler water resulted in very little relief; elimn. of greensand effected material improvement in turbine operation and performance owing to decrease of SiO_2 in steam. Seasonal anals. showed also that increase in content of SiO_2 on softening with greensand is function of temp. and of increased growth of organisms. Loss of SiO_2 from greensand increases with OH concn. and with total ion concn. in water supply. Suggested that SiO_2 in various degs. of hydration vaporizes from aq. solns. of alkali silicates.—*C.A.*

Five Ways to Remove Dissolved Silica From Boiler Feed Water. M. E. Gilwood. Power **91**:8:86 ('47). Ways outlined are with ferric sulfate, with Mg salts, by fluosilicate anion-exchange reactions, by direct absorption in exchange reactions and by combination treatment. All described.—*C.A.*

Foaming in Boilers Can Be Economically Controlled. W. H. Thompson & C. Jacklin. Power Plant Eng. **51**:7:80 ('47). Use of certain polyamines to control foaming described. Control testing procedure outlined. In case described, results good.—*C.A.*

Waterwalls: A Must With High Boiler Water Concentrations. Max H. Kuhner. Power **91**:7:72 ('47). Where boiler water concns.

apt to be high, waterwalls, owing to better heat distr., tend to reduce or moderate formation of boiler scale.—*C.A.*

Intercrystalline and Other Types of Corrosion of Steam Boilers. R. E. COUGHLAN ET AL. Am. Ry. Eng. Assn. Bul. 469, p. 66 (Nov. '47). Railroads testing all-welded boilers to prevent damage from intercrystalline cracking caused by adverse water conditions.—*R. C. Bardwell.*

Experience Shows Amines Stop Corrosion. R. S. MONCRIEF & M. E. DREYFUS. Power. **91**:1:19 (Jan. '47). Severe corrosion problems encountered in feed pumps, de-aerating trays and heaters of large Louisiana steam plant due to oxygen scavenged by corroding metal from condensate and feed water at their low pH range of 6.8–7.0. Water-sol. amine (compn. not given) introduced into system at initial rate of 4 ppm. and addnl. amine added at rate of 1½–2½ ppm. regularly. All equip. previously subject to active corrosion found to operate over long periods without giving any trouble. Description of plant included.—*Corr.*

Treatment of Corrosive Water. H. G. STAPLEY. Gas World (Br.) **127**:248 ('47). Water used in Exeter gas plant filtered to remove material in suspension. Water used for cooling in condensers treated with Na_2SO_3 to absorb D.O., and also with NaOH to raise pH value to 7.9. D.O. content reduced to 0.2 ml./hr. Boiler feed water softened by base-exchange process to zero hardness and finally treated with small dose of NaOH and tannin to prevent corrosion in boilers by CO_2 liberated by decompn. of $NaHCO_3$ formed in base-exchange softening process. Emulsified oil in condensed steam from feed-water heaters, compressors and exhausters removed by elec. de-oiling process before condensate returned to boilers.—*C.A.*

Photometric Determination of Dissolved Oxygen in Condensates and Feed Waters by Means of the Starch-Iodide Complex. S. BAIRSTOW, J. FRANCIS & G. H. WYATT. Analyst (Br.) **72**:340 ('47). Increasing use of boilers with working pressures over 250 psi. makes control of D.O. important. Thus, when pressure 600 psi., not more than 0.01 ml. of O_2/l. permissible. Winkler's classic method for detg. D.O. involves reaction of D.O. with $Mn(OH)_2$ pptd. in soln. and reaction of Mn_3O_4 formed with KI and acid to give free I_2, which is usually titrated with $Na_2S_2O_3$ in presence of starch as indicator. In original form, Winkler's method not suitable for use with modern feed-water supplies. Present paper describes accurate procedure for detg. liberated I_2 by measurement of intensity of starch-iodide complex with Spekker photoelec. absorptiometer. Convenient form of sampling app. shown in which necessary reactions can be carried out without atm. contamn. and effects of other interfering substances avoided. Procedure has been used for 6 mo. and over 400 routine detns. have been made. A 55-ml. sample of water suffices for anal. Full details given with complete bibliography.—*C.A.*

Correct Materials Make Feed Pumps Immune to Corrosion-Erosion. H. L. ROSS. Power **91**:7:86 ('47). Considered more desirable to select suitable pump materials than to develop feed-water control. Latter usually pointed toward better boiler conditions and may produce water dangerous to pump metal. Chrome and stainless steels described and discussed. Addnl. cost of these special metals considered justified.—*C.A.*

Survey of German Feed-Water Practice. W. W. CERNA. Power **91**:9:72, 158 ('47). Physically hard exchange resins have been used at temps. as high as 210–212°F. with water de-aerated and having max. pH value of 8.5. Silica removal based largely on use of Mg. Use of ammonia successfully developed. N has been used to prevent corrosion in stand-by or laid-up boilers. Many other phases of water use and treatment touched on.—*C.A.*

Feed-Water System Improved in Georgia Paper Mill. N. H. MAILHOS. Southern Power and Ind. **65**:10:64 ('47). Increased demands for steam and hence feed water met by installation of new treatment plant. First stage used Cochrane hot lime-soda process softener of 32,000 gph. capac., provided with stirring mechanism and vent condenser. Automatic sludge blowdown and recirculation provided. Existing softener modified for second-stage treatment using disodium phosphate and stirring mechanism. Water then filtered to give water of zero hardness at 220°F., low in SiO_2 and free from O and CO_2. Boiler blowdown therefore at min., with no operating difficulties due to scale formation. —*C.A.*

Feed-Water Conditioning Apparatus. JOSEPH F. SEBALD. U.S. 2,427,422 (Sept. 16, '47). App. described provided with means to impart whirling action to steam used for heating incoming raw water. Horizontal whirling action insures effective mixing of water and incoming reagents. Structural details given. —*C.A.*

Boiler Water Treatment. ANON. Wtr. & Wtr. Eng. (Br.) **50**:310 (June '47). Treatment prevents scale formation, corrosion, priming and caustic embrittlement. Scale formation—most common malady attacking boilers—results from chem. effect of heat on dissolved hardness of natural waters. Prevented by adding chems. to boiler water. Up to pressures of 200 psi., soda ash gives good protection against scale formation. Corrosion caused by acidity of water and presence of D.O., carbon dioxide, ammonia or other gas. Residual oxygen can be neutralized by sodium sulfite, iron hydrate, tannin and lignin. Priming and foaming caused by too high concn. of dissolved and suspended solids. This can be prevented by blowing down boiler. Blowdown should be done in small amts. Caustic embrittlement may be experienced with certain types of feed water, cryptocrystalline cracks forming generally at riveted seams below water level. Factors necessary to cause embrittlement: (1) presence of sodium hydroxide, (2) silica, (3) local concn. of strong caustic, (4) local region of high stress, (5) concd. caustic in contact with boiler metal.—*H. E. Babbitt.*

Water Supply for High-Pressure Boilers. H. O. TULCINSKY. Tech. l'Eau (Belg.) p. 13 (Nov. '47). Use of h-p. boilers presents special problems in treatment, requiring systematic study. Natural waters vary greatly and study of qual. of water necessary to arrive at profitable installations.—*W. Rudolfs.*

Wall-Tube Corrosion in Steam-Generating Equipment Operating Around 1300 psi. F. G. STRAUB. Trans. A.S.M.E. **69**:493 ('47). Several instances of boiler-tube failure of brittle and nonbrittle types described. In brittle type, metal decarburized under corrosion products on water side. Intercryst. cracks occur in decarburized areas. This type of failure may be due to presence of D.O. in feed water in absence of suitable O scavenger. Such errosion elimd. by use of O scavenger, removal of source of O contamn., and maint. of pH of at least 10.5. Nonbrittle type of corrosion due to caustic attack on tube metal, apparently caused by concn. of boiler water under iron oxide deposits adhering to tube walls. Grain structure normal in this type of corrosion, and no intercryst. cracking occurred. This condition remedied by coordinated phosphate pH control, so that only Na_3PO_4 free from hydroxide would be formed in concd. boiler water.—*C.A.*

Corrosion and Embrittlement of Boiler Metal at 1350-psi. Operating Pressure. L. E. HANKISON & M. D. BAKER. Trans. A.S.M.E. **69**:479 ('47). During winter of '44–'45, 3 boilers operating at 1350 psi. at Springdale Station developed type of barnacle corrosion and metal embrittlement that caused considerable apprehension for safety and continuous operating ability of boilers. Study of boiler history indicated that boiler metal surfaces prior to acid cleaning protected by iron sulfite-phosphate compd. and that acid cleaning removed this protective coating. Barnacle "seed" developed on unprotected surface during frequent boiler outages. This probably aided by relatively large amts. of O entrained in feed water when no scavenging material in use. Barnacles of cancerous nature developed from "seed," forming either large individual penetrating barnacles or uniting with adjacent small barnacles to form corrosion field. In either of these larger formations, H-embrittled metal developed underneath, as detected by deep etching; H embrittlement could not be detected under smaller barnacles by this method. Barnacle growth and embrittlement stopped when feeding of sulfite resumed. Reduction of O in feed water at about same time that sulfite resumed, however, may be factor in stopping this growth. Percentage of Cu and Cu oxide in boiler deposits relatively high; this has been lowered by reducing NH_3 content of boiler feed water. Boiler water pH has at all times been maintd. at about 11.1—*C.A.*

Simplified Plant Control Test for Boiler-Water Dissolved Solids. J. J. MAGUIRE & J. W. POLSKY. Combustion **18**:11:35 ('47). In detns. of solids content of boiler water, use of gallic acid shown to be preferable to H_2SO_4 as neutralizing medium in measuring conductance of boiler water. Advantages of gallic acid are its simplicity and accuracy.—*C.A.*

Investigation of Acid Attack on Boilers and the Effect of Repeated Acid Cleaning on the Metal. H. C. FARMER. Trans. A.S.M.E. **69**:405 ('47). Lab. investigation has been made of effect of inhibited cleaning acid (HCl) on stressed and unstressed boiler metal. Attack by inhibited acid can take place on stressed metals below 175°F.; to minimize this attack, boiler and solvent temp. should be reduced to not over 140°F. This can be realized by cooling down boiler and then reheating with hot water to temp. not over 160°F. When boiler metal temp. 140°F., acid soln. introduced. Acid strength should not exceed 5%; if boiler very dirty, 2-stage treatment should be used, without increasing this concn. Time of contact with given lot of acid should not exceed 6 hr.; for longer periods addnl. lots of acid should be used. At 140°F., stressed boiler steel will be attacked by inhibited acid; penetration of this attack will be governed by depth to which metal has been stressed and may not be very deep. Unstressed boiler steel shows some metal loss with inhibited acid at 140°F., but this is slight. Presence and amt. of ferrous Fe in boiler deposits may be factor in metal attack, since inhibitor does not protect steel from attack by ferric chloride. Total loss of boiler metal under conditions of 140°F., 5% acid, and 6-hr. contact time in presence of boiler deposits approx. 0.10 lb./sq. ft.; after 25 treatments, this amt. not serious. Loss twice as great at 175°F.—*C.A.*

FOREIGN WATER SUPPLIES—GENERAL

The Water Supplies in Bavaria, 1939 to 1946. HANS SEEBERGER. Gas u. Wasser (Ger.) **88**:2:52 ('47). Until '39, new plants under constr. could be finished; in next 2 years only upkeep possible. In '43 nearly all work stopped. In '44 work limited to repair and prevention of bombing damages. Since end of war much repair work being done as well as planning expansion of plants, 75% of which insufficient to satisfy demand. Water losses reduced somewhat but still avg. 6% in cities of less than 5000 pop., to 23.0% in cities over 100,000 pop. Per capita consumption increased over years and in '46 (including industries and losses) amtd. to only 21.2 gpd. in cities 2000–5000 pop., increasing to 100 gpd. in cities over 100,000 pop.—*Max Suter.*

Special Aspects of the Water Supply in the Industrial Area of Westphalia [Ger.]. FRITZ IMHOFF. Gas u. Wasser (Ger.) **88**:3:65 ('47). Industrial area about 1000 sq.mi. with pop. of 4,000,000. Although residential use of water only 30 gpd. per capita, total pumpage 580 mgd. About 68% of this water comes from Ruhr, 19% from Rhine and 13% from Lippe Rivers. Emsch R. flows through dist. but used as sewage collector. Ruhr comes from timbered hills and has water with hardness of 107–125 ppm. Since '13, 12 storage reservoirs built with total storage of 21,500 acre-ft.; Möhndam largest, retaining 10,700 acre-ft. Poln. of Ruhr reduced by works of Ruhrverband. Water in Ruhr Valley obtained from gravels 13–16' thick lying under clay 4–7' thick. This gravel satd. by infiltration from Ruhr and from artificial basins, 1000' × 66', dug into gravel and covered with 20" of sand. Rate of infiltration in these basins 1–2 mgd. per acre and they require skimming of top sand every 2–3 months. Estd. that 70% of infiltrated water comes from basins. In Rhine Valley water obtained from wells in gravels 33–66' thick. This water has hardness of 160 ppm. and varies greatly in its levels due to 30' changes in the Rhine R. Lippe water from salt springs too salty to be used, but springs and side creeks used in Lippe Valley. Generally pumpage done by steam. Piston pumps in units up to 8800 gpm. in use. Steam turbines efficient, but they as well as elec. or Diesel power subject to longer interruptions during war, especially after bombing of Möhndam Res. on May 12, '43. 7000 mi. of distr. system consists mainly of cast iron; for sizes over 20", steel pipes used. Cast-iron pipes are flange-bolted, steel pipes welded. System designed to limit pressure losses to 2' per 1000'. Water plant suffered little from bombings, but distr. system had about 20,000 breaks. Its rehabilitation still difficult due to lack of labor and material; water works operates now with 50–80% of wartime capac.—*Max Suter.*

Notable Water Undertakings. V. The Hartlepool [Gt.Br.] Gas and Water Co. ANON. Wtr. & Wtr. Eng. (Br.) **50**:459 (Sept. '47). Hartlepool Gas and Water Co. celebrated centenary last year. Story of rise of West Hartlepool could almost be written from records of company. Today company has 2

systems of supply, domestic and industrial, with suburban extensions. Domestic supply drawn from site of old quarry where water rises in boreholes from depths of 80–300′, to within 20–25′ of ground surface. Boreholes deliver water to common sump from which it is pumped to storage towers and thence gravitates to consumers. Pop. of about 91,-000 supplied, avg. amt. of water delivered, including industrial, being 5.32 mgd. (Imp.) or 58 gal. (Imp.) per capita.—*H. E. Babbitt.*

The History of the Water Supply of Kingston Upon Hull [Gt.Br.]. ANON. Wtr. & Wtr. Eng. (Br.) **50**:556 (Nov. '47); The Engr. (Br.) **184**:384 (Oct. 24, '47). Inquiry into value of convent property in Wyke and Myton by jury on Jan. 3, 1293, resulted in report that said, among other things, that town of Wyke abundantly supplied with fresh water which comes from place called Springhead. As time went on inhabitants of Hull annexed springs adjacent to Springhead. Among records is curious missive, issued by College of Cardinals at Rome in 1415 urging cessation of all efforts to injure people of Hull by depriving them of their water. About 1460 Sir William Knowles laid system of lead pipes in streets. System did not work and pipes were taken up. In 1616 water company formed which took over town supply. In 1795 steam engine erected by James Watt to raise water from dike to cistern. In 1832 borough extended and water flowing from springs insufficient. In 1845 Stoneferry water works opened. Water taken from river for about 2 hr. at ebb of tide. In 1849 there was cholera epidemic with 1860 victims. In 1858 Warden obtained almost 5 mgd. (Imp.) from Springhead. In 1876 Woodhouse engine started, still in working condition. This is Cornish beam engine with 90″ cylinder and 11′ stroke. In 1884 corporation empowered to obtain water at Mill Dam. In 1893 corporation purchased works of Newington Water Co. In 1911 obtained powers to construct works at Dunswell. Today Springhead, Mill Dam and Dunswell pumping stations, together with small pumping station at Swanland, provide water, supply being obtained from wells, bores and adits constructed in chalk strata.—*H. E. Babbitt.*

The Works of the Kingston on Hull Undertaking. ANON. Wtr. & Wtr. Eng. (Br.) **50**:580 (Dec. '47). 6 pumping stations, pumping from wells in chalk. At Springhead 2 vertical, triple-expansion engines and 1 Cornish engine. High-level supply pumped by direct-action, triple-expansion horizontal engine and 1 cross-compd. rotative engine. At Mill Dam 3 triple-expansion vertical engines. At Dunswell 2 three-throw pumps each of 5-mgd.(Imp.) capac. Bilton is boosting station contg. 2 turbine pumps each of 60,000-gph.(Imp.) capac. At Swanland 16-bhp. submersible, electrically operated pump installed. Keldgate contains 2 electrically driven 12-bhp. centrifugal pumps. 3 covered reservoirs: Keldgate No. 1 with capac. of 10 mil.gal.(Imp.), Keldgate No. 2 with capac. of 8 mil.gal.(Imp.) and Raywell with capac. of 0.54 mil.gal.(Imp.). 4 water towers with total capac. of 0.912 mil.gal.(Imp.). Various sections of department housed in Central Depot. Prospective works involve impounding waters from Farndale area. Waters can be brought into Farndale Res. by means of tunnels, and intervening surface streams collected by means of bores sunk from stream beds to tunnels. During war pumping stations and Central Depot received extensive damage, 394 mains fractured. Damage sustained amtd. to £37,600.—*H. E. Babbitt.*

London Water. ANON. Engineering (Br.) **164**:397 (Oct. 24, '47). Thames R. flows approx. along center line of London basin syncline. Chalk, on which London clay superimposed, supposed to have been laid down in sea of great extent. London basin, from water supply viewpoint, constitutes self-contained area which extends from mouth of Thames to Newbury in Berkshire and from Chiltern Hills to North Downs. Water Board scheme proposed coordination of water supply over area extending from Baldock in north to Horley in south, and from Maidenhead in west to Gravesend in east. It would cover area of 2754 sq.mi. Water Act of '45 suggests formation of Joint Advisory Water Com., but board considered more drastic revision desirable. 28 local authorities and 29 water companies that opposed board's proposals suggested that by amalgamation number of participants concerned could be reduced. Board's proposal for entirely new body businesslike and sensible.—*H. E. Babbitt.*

The Case of the Fifty-Seven Undertakers [Gt.Br.] ANON. Wtr. & Wtr. Eng. (Br.) **50**:572 (Dec. '47). Opposition to proposals of Metropolitan Water Board for setting up of "Greater London Water Area" came from

group of 57 operators representing virtually every water utility in affected area. Sir Cyril Radcliffe, representing objectors, based opposition on following points: (1) Seemed clear that board's proposal departed entirely from national policy laid down in '45 Act. Boundaries of regions can be delimited only after consultation by Minister of Health with authorities concerned. (2) Argument that irregularity of boundaries of water undertakings bad in itself can be answered by question: if whole area taken over by single authority what will be done to correct effect of distr. within irregular boundaries? (3) Special mains for bulk supplies will, of course, be laid toward boundaries, to meet criticism that mains taper in size toward boundaries. (4) Comparison of admin. eff. of proposed area with any other water undertaking impossible because of discrepancy in size. (5) Amalgamation already planned refutes suggestion that it would not be done voluntarily. (6) Proponents' statements about coming crisis vague. (7) Potential water surplus of area outside of Metropolitan Water Board had been computed as 72 mgd.(Imp.). (8) Consumption in "outer area" deducted from total resources of 572 mgd.(Imp.) would leave enough for 62 gpd.(Imp.) per capita for 6,200,000 occupants of "inner area"—ample amt. (9) Counter proposals by undertakers were that the Greater London Water Area, and perhaps addns. to it, should be covered by number of Regional Joint Advisory Water Committees. (10) Tables with regard to bulk supplies by undertakers in this area do not show sign of hopeless obstruction or battle between those separate organizations. (11) If you threw all organizations out and put one in their place you would find that it was dealing with much same situation as they are handling today. (12) Neither regional nor functional organization on large scale would achieve real contact with public. (13) Working expenses per 1000 gal. in '44–'45, in cases of company and local authority, both below those of Metropolitan Water Board. Cost of decent water supply in outside area does not call for merger for cheapening cost to consumer. D. M. Fyfe, replying for Metropolitan Water Board, stated: There were obvious differences between emergency supplies and regular bulk supplies. If there were to be one integrated authority, there would not be need for emergency supplies; it was always contemplated that there would have to be special treatment for Metropolitan Area. Water Act was intended to deal primarily with smaller and local problems.—*H. E. Babbitt.*

The Manchester Water Undertaking, 1847–1947. From brochure published by City of Manchester. ANON. Wtr. & Wtr. Eng. (Br.) **50**:490 (Oct. '47). Manchester undertaking, second largest in United Kindgom, celebrates centenary. During greater part of 16th and 17th centuries water obtained from wells and springs, chief source being well in Fountain St. In 1846 corporation promoted bill to acquire works of Manchester and Salford Water Works. Bill received royal assent on July 9, 1847. Seven reservoirs have been constructed in Longdendale Valley. Lake in Thirlmere watershed closed by masonry dam 54' high. By '14 rate of water consumption demanded acquisition of new source of supply. As result, water level in Haweswater, lake 80 mi. from Manchester, raised 95' by constr. of dam across Haweswater Beck. Length of dam at top water level 1550', with max. height of 120', forms reservoir with capac. of 18,662 mil.gal.(Imp.). Haweswater Aqueduct to Heaton Park Res. in Manchester will be approx. 72.7 mi. long. 11 service reservoirs with total storage capac. of 2487 mil.gal.(Imp.), 1656 mi. of trunk and service mains 3–44" in diam. Unaccounted-for water about 4%. Lakeland supplies of excellent qual. throughout year. Small amt. of lime added to increase [*sic*] hardness, and water passed through automatic fine strainers and finally sterilized with chloramine. Longdendale supply discolored by peat during and after stormy weather and exptl. filtration and ozone treatment plant under constr. Total quant. of water supplied for all purposes about 75 mgd.(Imp.). Total capital outlay £13,645,866. Expenditure for '47 was £1,070,453, with income of £1,076,968.—*H. E. Babbitt.*

National Parks and Water Supply [**Gt.Br.**]. ANON. Engineering (Br.) **164**:494 (Nov. 21, '47). Pure water in adequate quant. more important even than elec. light. Increase in water demands has forced many large cities to tap water sources in remote dists. This procedure has raised new problem in recent years. Information about national park policy given by John Stewart before Royal Sanitary Assn. of Scotland last month. Suggested that if National Parks Bill drawn up there should be consultation between ap-

propriate minister and water authorities affected. If water undertakings unable to accept findings, their areas should be omitted from scheme.—*H. E. Babbitt.*

The Construction and Operation of a Small Water Purification Plant [Gt.Br.]. L. B. MITCHELL. Originally published in J. Inst. of Munic. Engrs. Wtr. & Wtr. Eng. (Br.) **50**:533 (Nov. '47). Plant in question designed and constructed during war for service establishment in north of Scotland. Has proven successful. Anticipated max. demand was 100,000 gpd.(Imp.), basic proposals of scheme being: (1) to draw water from lake and deliver it by low-lift pump into reaction tanks, injection of alum being made between pump and tank; and (2) to remove as much suspended matter as possible in reaction tanks and pass water, by means of high-lift pumps, through pressure filters, dose with soda to raise pH value, with chlorine and ammonia to sterilize, and finally to pump through rising main to high-level storage tank of 100,000 gal.(Imp.) capac. No real difficulties encountered during constr. Found that any reasonably intelligent man soon became proficient in operation of plant. Normal chem. doses, varied in accordance with raw water, are: alum 44.3 ppm., soda crystals 50.1 ppm. and ammonia sulfate 1.2 oz. per gal.(Imp.) Daily tests made to ascertain pH and free chlorine values of treated water. Final cost of very nearly 6.86 pence per 1000 gal.(Imp.) reported. Scheme designed and built in great hurry and materials and labor scarce. Scheme open to objection on grounds that failure of power brings plant to standstill. In winter of '45 when ground temp. of 0°F. persisted for some time, ice on tank surfaces became several inches thick and delivery pipes on outside walls of tank froze. Corrosive properties of water high and most service pipes ungalvanized. Proposed to install small lime-dosing plant which will raise pH and deposit layer of calcium carbonate on pipes.—*H. E. Babbitt.*

Modern Water Treatment in Warm Countries [Iraq]. O. L. RENSONNET. Tech. l'Eau (Belg.) p. 17 (Oct. '47). Description of treatment plant at Dhibban in Iraq about 60 mi. from Baghdad. Water obtained from Euphrates and contains up to 10,000 ppm. suspended solids. Water settled, flocculated with avg. of 14 ppm. alum, and resettled before going to rapid sand filters; gaseous chlorine used for sterilization.—*W. Rudolfs.*

Neapolitan "Jug and Bottle" [Italy]. H. D. SNOW. Wtr. & Wtr. Eng. (Br.) **50**:506 (Oct. '47). As German forces retreated they disrupted water, elec., gas, and transport services. Rain had fallen torrentially night before Oct. 1, '43. As Allies entered that day inhabitants seen scooping water from puddles and sewer manholes. Main Serino Aqueduct cut and Capodimonte Res. had been mined. Scudillo Res., with capac. of 13 mil.gal. and Quota Res., with 2 mil.gal. believed to be intact. Carmignano Aqueduct dry. Bolla Aqueduct used for industrial supply, street washing and public fountains. Following day reconnaissance for private supplies revealed deep boreholes located at refrigeration plant, bank, flour mill, brewery, laundry and town square. Meanwhile U.S. Army engrs. busy establishing water points at undamaged reservoirs and Bolla Aqueduct. Water pumped into 3" header pipe, raised about 2' 6" above pavement level with row of taps spaced on 3' centers. Taps too close together caused some disorder. By end of Oct. good progress made in restoring water supply. Germans had been pushed off Serino Aqueduct. Americans had repaired break near Avillino, and civilians had repaired Capodimonte reservoir and major breaks in street mains. By Nov. 12 water supply around Vesuvius restored to 3 mgd.(Imp.). Civilian water engrs.' troubles not over. Returning inhabitants occupied all available buildings. When water eventually turned on, sometimes found heavily polluted. Some units camped along pipelines tapped mains with wasteful results. Vesuvius erupted and lava flowed towards pipeline which was cut between Massa Somma and Sebastiano, and lava halted only 80 yd. from main Vesuvius pipeline.—*H. E. Babbitt.*

Mineral Water of Mohara in Chiba Prefecture [Japan]. I. KAZUO KURODA Sci. Papers Inst. Phys. Chem. Research (Tokyo) **39**:378 ('42). Temp., pH, evapn. residue, and output of 17 mineral springs at Mohara measured. For detn. of I, following method recommended: To 50 ml. of sample add 1 ml. concd. H_2SO_4 and 10 ml. $NaNO_2$ soln. (10%), shake 3 times and remove with 10 ml. CCl_4 in separating funnel, measure violet color of CCl_4 layer. For detn. of Br, remove I from 50-ml. sample by boiling with H_2SO_4 and

$NaNO_4$, add 65 ml. AcOH (1:2) and 10 ml. $KMnO_4$ soln. (2.5%), ext. Br by CCl_4 from soln., and measure color of CCl_4 layer. I, Br, and Cl content of 17 springs given and their relations to contents discussed.—*C.A.*

Domestic Water Supply in Palestine and Syria. Eric Hardy. Wtr. & Wtr. Eng. (Br.) **50**:504 (Oct. '47). Water in Jerusalem usually rationed during summer drought, but always safe, usually chlorinated. In Arab villages water drawn from wells. Modern petrol can is universal article of household use in village life. In Jerusalem 2 main sources of water supply: ancient reservoirs known as Solomon's Pools and water brought by pipeline from Yarkon R. Further source lies close to spring of Ein Fara from which water pumped through pipeline to Holy City. Tel Aviv and Haifa have raised greater problems of water supply. Jewish Mekoroth Water Co. supplied Haifa with 2,750,000 cu.m. of water in '46. In Arab villages goats and Arabs drink from same well and goatskin container. Most of rivers infested with germs of bilharziasis and schistosomiasis. Most Arabs near river courses infected, and pass eggs in urine. One snail may discharge 2500 cercariae daily for 68 days. Some years ago Teheran obtained water for domestic use from open gutters that ran down streets of city, which were used communally for washing and bathing. Damascus receives water supply from perennial Barada R. which flows under city and also takes away sewage. Here, as in some parts of Palestine and Trans-Jordan, malaria widespread owing to faulty and unclean cisterns. Beirut and Lebanon coast have 14 munic. sources of supply producing approx. 7.75 mgd.(Imp.). Reliance can be placed on native cisterns only in winter rainy season. In desert country of Trans-Jordan most of water obtained from deep boreholes, as at Mafraq and H5.—*H. E. Babbitt.*

Water Supplies in the Middle East Campaign. X. Trans-Jordan. G. L. Paver. Wtr. & Wtr. Eng. (Br.) **50**:442 (Sept. '47). Development of water supplies for Trans-Jordan took place in conjunction with development of 2 main routes: Aqaba-Maan-Amman road and rail route and Haifa-Baghdad road. Topographically Trans-Jordan may be divided from east to west into: (1) Rift Valley Area, comprising low-lying areas of Jordan Valley, Dead Sea and Wadi Araba; (2) Escarpment Area, rising abruptly from low-lying Rift Valley and attaining el. of 750 to 1500 m. Area receives majority of rainfall of Trans-Jordan; and (3) Desert Area, commencing east of main north-south route through Maan-Amman-Mafraq. Area plateau at el. of about 1000 m. Hydrologic areas are: northern region—some springs const., and some seasonal; central region—large springs in Dead Sea Valley with 3 water horizons in cretaceous rocks, some good qual. supplies, and in Majeb basin springs largely inaccessible; southern region—small supplies, some inaccessible, with seasonal high-altitude springs in Shera basin. Geologically Trans-Jordan includes numerous rock strata, mostly limestones; main water supply sources can usually be associated with specific geological structures or strata. New development of underground water resources has followed geophysical survey. Application of geophysics may be summarized as follows: Resistivity measurements to locate and est. depths of water table and to elucidate subsurface structure; and magnetic measurements to trace major faulting of granite basement and to locate and follow dikes in granite area. Underground water provinces in Trans-Jordan are: (1) limestone country of north and central Trans-Jordan—yields of order of 250–1000 gph.(Imp.) and qual. usually good; (2) Nubian sandstone country of southern plateau area—low rainfall area in which water is scarce, supplies at considerable depth, yields as low as 100–200 gph., qual. mediocre; and (3) coastal area near Aqaba—water occurring as water table at sea level, water developed on aqueduct system to draw only upon top of water table, qual. only fair. —*H. E. Babbitt.*

South African Notes. The Water Resources of the Union. Anon. Wtr. & Wtr. Eng. (Br.) **50**:514 (Oct. '47). Scarcity of water will limit within 30 yr. industrial expansion and number of people that can be supported unless rivers nationalized and riparian principle of water usage abolished. Union, particularly on plateau, has poor natural water supplies which are capable of retention on land; misuse of land reduced what little water available by erosion; legal principles governing use of water unsuitable to local climatic conditions; present unnecessary high priority for use of water for irrigation purposes should give way to priorities for any purpose in best interests of country; there are limits to agricultural and industrial development of Union and to number of people it can support

in reasonable comfort. Govt. proposes to spend £400,000 on first part of £2,500,000 scheme to supply water to new gold mining areas in northern Orange Free State. Provision made to increase storage capac. of Vaaldam to nearly 2,000,000 acre-ft. Minister of Lands and Irrigation said recently that needs of Bloemfontein must have priority over those of farmers. Dam to be built in Umlazi Native Reserve will have capac. of 300 mil.gal.(Imp.). Latest figures on cost of Umgeni Dam and Lower Table Mt. water scheme (for Durban) total £3,469,000. Private irrigation scheme has recently built, in Bedford Dist., storage dam with capac. of 453 mil.gal.(Imp.). Small municipalities given 33.3% subsidy on dams up to £10,000 or, with consent of parliament, govt. can bear full cost. Obstacles to progress lack of initiative on part of some local authorities and jealousies of others. Little integration of water and soil conservation schemes. Problem of poln. not tackled adequately.—*H. E. Babbitt.*

Research on Problems of Water Pollution and the Treatment, Disposal or Utilization of Sewage and Trades Waste in South Africa. HAROLD WILSON. Inst. Sewage Purif. J. and Proc. (Br.) Pt. II, 164 ('45). Need for plant-scale research in sedimentation and in coagulation of sewage colloids to furnish data to meet varied demands of South Africa. Program on national scale proposed.—*C.A.*

South African Irrigation and Water Supply Schemes. ANON. The Engr. (Br.) **184:** 146 (Aug. 15, '47). In June '47, House of Assembly voted £2,500,000 for carrying water from Vaal to Odendaalsrust. Dept. of Irrigation will supply 5 mgd. (Imp.) to new gold mining areas in Free State. Increased by 2 mil.gal. per yr. until reaches 50 mgd. Vaal dam will ultimately be raised 18′. Whole of Vaal basin will be developed industrially. Prelim. work has been started for Free State involving constr. of 2 dams at Allemanskraal and Erfenis on Sand and Vet rivers. Only 6 mi. of pipeline now separate Port Elizabeth from Churchill Dam with capac. of 7800 mil.gal. (Imp.). New water scheme has been started along Durban south coast. Water will be drawn from Nongwana R. from reservoir to have capac. of 300 mil. gal. (Imp.). Govt. proposes to provide storage on Ohrigstad R. in Northern Transvaal by building dam 173′ high, and dam on Levubu R. 86′ high.—*H. E. Babbitt.*

STERILIZATION

The Dynamics of Water Chlorination. G. M. FAIR, J. C. MORRIS & S. L. CHANG. Water (Neth.) **31**:165 (Aug. 21, '47). Disinfection of water by means of chlorination affected by nature of organisms to be destroyed, their possible concn., contact time, concn. of chem. agent, temp. of water, and concn. and compn. of impurities present in water to be disinfected. Assumption that chem. reaction takes place between chlorine and organism to be killed proved fruitful in investigations. When gaseous chlorine dissolved in pure water it reacts with water essentially completely to form HOCl and HCl. Tests with cysts of *E. histolytica* showed that killing action due primarily to HOCl. Sterilization strongly affected by pH. Results obtained for destruction of amebic cysts by chloramine at 23°C. show that for contact time of 30 min., dichloramine about 66% as effective as HOCl and monochloramine about 22% as effective. For spores of *B. anthracis* dichloramine had only 15% effectiveness of HOCl. Effect of concn. of disinfectants (c) and killing time required (t) can be expressed as $K = c^n t$. In general, disinfection (e.g., reaction) increases twice by increase of temp. of 10°C. Difference in resistance of different types of organisms and portion of difference in eff. of various halogen compds. may be correlated with resistance of cell wall to diffusion, so that cysts with greater cell wall thickness more resistant than bacteria. Studies of dynamics of disinfection process of fundamental importance for more reliable sanitary control of water supplies.—*W. Rudolfs.*

Apparatus for the Application of Chlorine. WILHELM GANDENBERGER. Gas u. Wasser (Ger.) **88**:3:73 ('47). Various German types of chlorinators described. In most of them chlorine first dissolved in water to concn. of 3000–6000 ppm. and this soln. dosed into distr. system. In some types this done without pressure, in others pump added for injection into pressure lines. To increase proportion of hypochlorous acid, one type passes chlorine soln. through marble to reduce HCl content. Some app. have manual regulation, others

automatic regulation proportional to water flow. Chlorinating app. should be in separate room kept at temp. not below 60°F. For small installations chlorine solns. introduced from tank through siphon. Concn. should be selected to give dosings of 12–20 ml./min.—*Max Suter.*

The Mechanism of the Hydrolysis of Chlorine. J. C. Morris. J. Am. Chem. Soc. **68**:1692 ('46). Results of expts. made by Shilov and Solodushenkov to det. rate of hydrolysis of chlorine in water tabulated. From calcns. of hydrolysis rate const. and energy of activation of reaction, author considers that exptl. results best explained by assuming that chlorine reacts with hydroxyl ion, and not with water molecule, as had been previously suggested.—*W.P.R.*

Vegetable Dechlorinating Substances. I. A. Bulichev. Gigiena i Sanit. (U.S.S.R.) **10**:13 ('46). While superchlorination regarded as best method for disinfection of water, its use is restricted because of scarcity of dechlorinating substances. Present work undertaken in order to discover dechlorinating substances which could be employed as substitutes for chems. used for this purpose. To this end series of vegetable substances tested and following proved capable of binding chlorine in adequate quants.: powd. briar hips, briar leaves and wood; leaves of oak, hazel, Amur vine, apple tree, birch; needles of pine and cedar. Material for dechlorination prepd. in form of powders, infusions and concoctions; no special app. required. Disinfection of water in cisterns, casks and smaller containers effected by superchlorination, and followed by dechlorination with vegetable substances, insures supply of water of good qual. This method of dechlorination also recommended for use in wells.—*B.H.*

Treatment for Potable Waters. A. Le Strat. Chimie & Industrie (Fr.), p. 346 (Oct. '47). Despite war difficulties, public water services in France maintd. to deliver pure supplies. Even after heavy bombardments water distributed to consumers and no reports made of increased mortality due to pold. water during hostilities. But research into hygienic water science in abeyance. Author follows investigation abroad, more particularly in U.S.A. and discusses free residual chlorination, also importance of ammonia dosage in chloramine treatment. Author remarks on value attached to chlorine in Anglo-Saxon countries to exclusion of other antiseptics; peroxide of chlorine, though at present revealed as dangerous to prepare, could be at first obtained from chlorites, perhaps prepd. in industrial process. Ozone in England has received only scant attention. Free residual chlorination now engages interest of water hygiene specialists. It may be called perfecting of process or rather superchlorination rationally conceived. Houston pioneer of superchlorination followed by dechlorination, but Howard, of Toronto, first to apply method on large scale for higher purity and removal of taste and odor; necessary where there is gross poln. and much org. matter. In France such conditions rare; preference given there to deep ground waters; if surface sources have to be taken, no doubt free residual chlorination will be used with other treatment.—*Ed.*

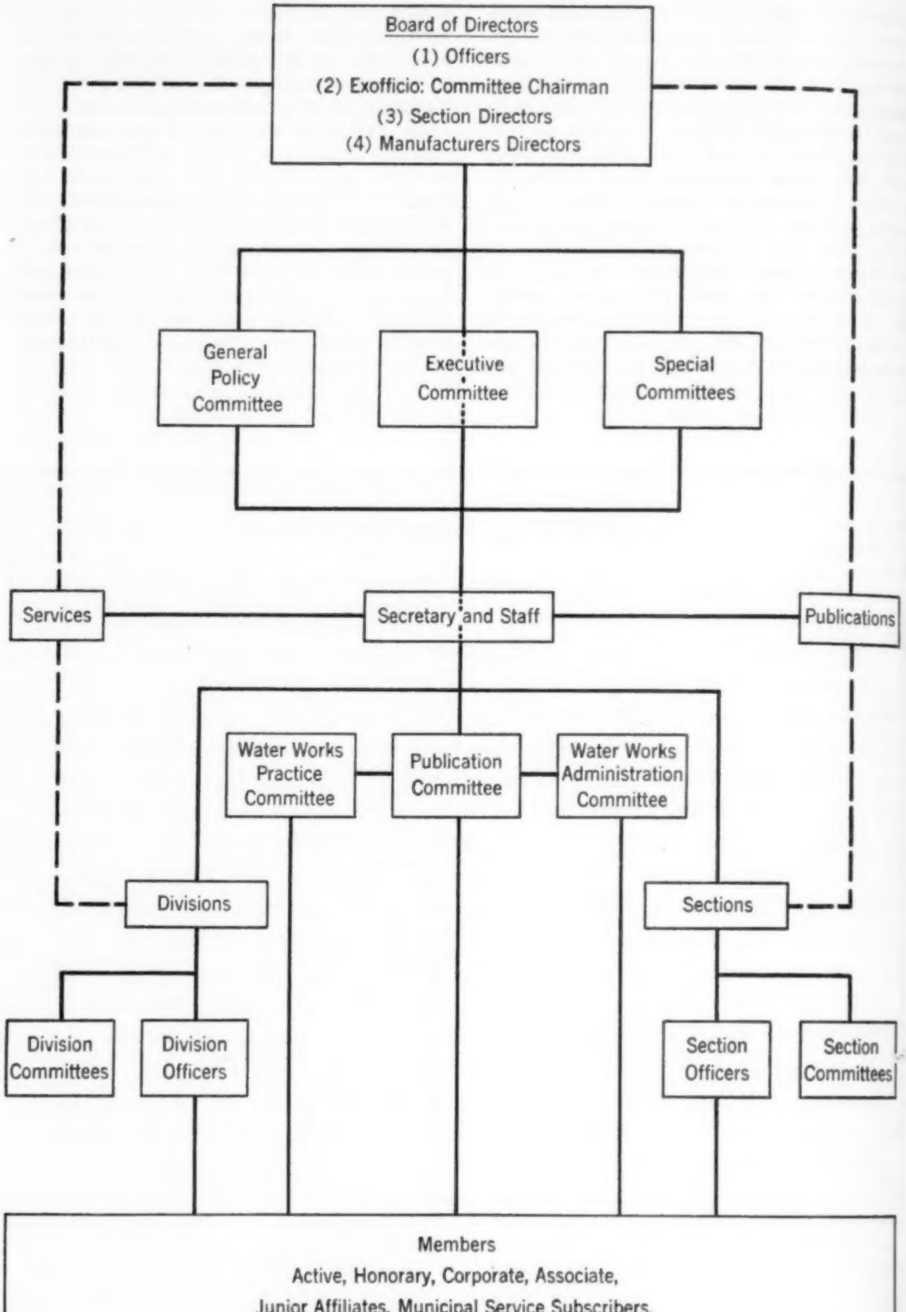
The Chlorination of Drinking Water. Anon. Gas, Wasser, Wärme (Ger.) **88**:2:45 ('47). Chlorination considered purely as safety measure. Am. Military Govt. requires 0.4 ppm. residual chlorine after 30 min. contact. Author seems to consider this somewhat in excess of safety requirements. Various methods of chlorination listed, with their types of application. [Article somewhat out of date; considers disinfecting action of chlorine to be due solely to effect of nascent oxygen, lists chlorinated copperas (coagulant) as source of free chlorine, neglects chlorine dioxide and does not mention anything about free residual chlorination.] Gives 2 interesting examples of use of chlorine, one in rural supply in which sodium hypochlorite used because of its easy handling, and in city ground water supply affected by phenol wastes, in which superchlorination followed by partial dechlorination with activated carbon filters used.—*Max Suter.*

Water Purification Problems in Singapore During Japanese Occupation. J. F. Clark. Commonwealth Engr. (Australia) **33**:417 (July 1, '46). During last few days before fall of Singapore and during Japanese occupation considerable ingenuity displayed in successful operation of munic. water purif. plant. During surrender period and afterward, until removed to prison, munic. officers responsible for public services carried on with their work. Conditions those of internment. Officially retained to supply any information required by Japanese officials imported to run various depts. 3 of imported water engrs. were dentist, lawyer, and toy shop assistant. No chems. available for water treatment and

chlorine stock running short. Sanitary conditions in catchment areas and about overcrowded towns, where many of water mains damaged, made it essential to maint. most wholesome water supply possible to minimize risk of epidemic disease. Decided to mfr. chlorine locally. Salt rationed commodity but sea water available. Lab. expts. on production of sodium hypochlorite from salt solns. and sea water of various concns. led to conclusion that proportion of chloride to available chlorine would be too high for product to be used for dosing water for domestic purposes. Since disinfectants scarce, however, resulting hypochlorite-salt soln. used quite extensively in hospitals and clinics, and proved to have marked healing effect on open sores. Attention turned to production on lab. scale of chlorine as gas, using carbons and porous pots from wet Leclanche cells scrapped by telephone company. Large cell then constructed and numerous modifications made before satisfactory production unit ready for operation. By electrolysis chlorine gas produced from purified satd. brine soln. and fed through hydraulic collecting main and suction pump into water main. Salt wastage high and evaporator built which recovered for further use about 80% of salt otherwise wasted, and could produce alkali of about 25% NaOH satd. with salt.—*P.H.E.A.*

A.W.W.A. Organization

The members of the American Water Works Association have organized themselves (*see* chart, following page) upon a regional basis into Sections and upon a professional basis into Divisions. Each regional Section elects a Director, who serves on the Board of Directors and who represents the members of his Section in all matters of policy and administration. Three correlating committees—Water Works Administration, Water Works Practice, and Publication—serve under the jurisdiction of the Board and draw their personnel from the membership of the Association. The Secretary and Headquarters Staff act as a coordinating agency for the standing committees, the Divisions and the Sections, and report to the Board or to the Executive Committee of the Board. The Headquarters Staff also edits the JOURNAL and provides members with such special services as may be requested. The General Policy Committee acts for the Board in examining questions of long-term importance and reports to the Board. The Board includes, in addition to the representatives of the Sections, three Directors representing the Manufacturers Association and the chairmen of the Committees on Water Works Administration, Water Works Practice, Publication, and General Policy.



A.W.W.A. Organization Chart

(See preceding page for explanation.)